Agroecological evaluation of the intensified cropping systems in the Red River Delta,Vietnam(Dissertation_全文)

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CONTENTS

Chapter 1. Introduction

1.1. Background and objectives

Among Southeast Asian countries characterized by a sparse population, upper Burma, east and central Java, and the Red River Delta of Vietnam are well known as exceptionally overpopulated areas. The Red River Delta is especially prominent in being overpopulated.

According to statistics of 1997, the agricultural population of the 9 provinces which make up the Red River Delta, was 10,737,000, on agricultural land of 6,723 km^2. The agricultural population density was, therefore, 1,597 person/km^2 (General statistical office, 1999). The rural Red River Delta is characterized by being an overpopulated area compared with other delta areas in Southeast Asian countries.

A high population density in a rural area means that the amount of land per person is limited. The agricultural population in the delta divided by agricultural land is a density of 672 m^2/person and divided by paddy land is 577 m^2/person, respectively. This shows that the farmers in the delta carry out their farming activities on small plots of land.

What is the effect of a high population density or of farming activity on small plots on the agricultural systems in the Red River Delta?

From the viewpoint of human ecology, Cuc and Rambo described the perspective of a village characterized by "*too many people, too little land*" in the Red River Delta (Cuc and Rambo 1993). In this book, Rambo states that demographic factors – more than social, economic, or political considerations – are the preeminent determinants of the structure and functioning of the village agroecosystem, and he shows that the various ecosystems are interlinked to form the village agroecosystem by flows of energy, materials, and information (Rambo 1996).

Sakurai (1999) suggested that a high population density has been a phenomenon since the 19th century and it gives agriculture in the Red River Delta the following distinctive features: a low labor-productivity due to intensive landuse and farming activities to maintain the overpopulation, construction of a village structure based on small householders because of undeveloped land-accumulation, efficient food-distribution under the condition of overpopulation, construction of a cooperated system to create burdens such as equality of tax, and shifting of the working population from the rice-cultivation sector inside the village to non rice-cultivation sectors inside the village and job work sectors outside the village.

Although, including the complex agro-ecosystem described by Rambo (Rambo 1996), it can be presumed that these features originated from overpopulation and have been historically formed, the relationship of cause and effect is not clearly certain.

The purposes of this study are, therefore, (1) to describe the status of agricultural production in the rural Red River Delta under the condition of "overpopulation", and (2) to evaluate the intensification from the viewpoint of agricultural production. This is because "overpopulation" in the rural area results in a small amount of agricultural land per farmer, and agriculture on a small plot of land must be intensified to support the "overpopulation."

In this study, the following indices of intensification were evaluated, 1) land intensification, which is the total area used per unit area, 2) labor intensification, which is the total working hour per unit area, and 3) capital intensification, which is the total amount of input per unit area.

Agricultural intensification of the Red River Delta is evaluated on the basis of these three intensifications.

This study consists of 5 parts.

Chapter 2 presents an outline of the village studied. The physical conditions of the village and the surroundings are described.

Chapter 3 classified the land by cropping patterns. In order to understand the outline of the village agriculture, the agricultural land was divided into 8 types, based on present and past cropping systems and their changes. Physical conditions and technical aspects were considered as determinant factors to the village cropping system.

Chapter 4 focuses on rice cultivation. The effects of physical conditions and cultivation techniques on cropping patterns and annual changes in rice yield are considered. Labor and capital intensification of the rice cultivation is evaluated.

Chapter 5 focuses on intensification of vegetable production cultivated on small plots of land as cash crops. The effects of cultivation techniques at the village level and farmers level on vegetable production are examined to evaluate the intensification.

Chapter 6 discusses potato production as a fund-raising activity by the cooperative because the cooperative is a factor in determining the village-level cropping-systems. On the basis of revenue and expenditure on potato production, the roles of the cooperative in the village agricultural system are evaluated.

1.2. Research method

The Coc Thanh Cooperative (hereafter called "CT"), Thanh Loi commune in the Vu Ban district of Nam Dinh province, located in an area in the lowest part of the Red River Delta, was selected for the present study

(Fig.2-3.). This is the village where the Japanese and Vietnamese association of Vietnamese village studies has conducted a series of interdisciplinary researches since 1994. This association, which was initiated by Dr. Sakurai Yumio, a professor of Southeast Asian history in the University of Tokyo, consists of researchers whose fields are history, sociology, anthropology, linguistics, agronomy, and other fields. The author is also a member of the association and has participated in a series of researches since 1994. The research of the association is still continuing in CT at the present time (2000).

For a fixed-point village study, the association selected CT as a study village in the Red River Delta in 1993, when foreigners were permitted to conduct a village study for the first time. The reasons why the association selected CT as a study village were: 1) there were historical documents and an accumulation of academic studies on its history at the village level, 2) the effects of a large city could be minimized because it is 60 km from the metropolitan area of Hanoi, 3) it is located in the central part of the lowland area of the Red River delta, and 4) the main economic activity is agriculture.

The research period every year has been about 3 weeks in the summer season. The members of association stay at a hotel in Nam Dinh City and go to CT in the morning and come back to Nam Dinh City in the afternoon by bus because staying overnight for a few weeks at a village is not permitted for foreign researchers.

Research since 1994 has included many types of studies. Research results have been published by the association in the journal "*Thong Tin Bach Coc* (Bach Coc Information)" vol. 1-9 (until 1999).

The author is indebted to *Thong Tin Bach Coc* for the present study. Especially the *xom B* basic data of 1995 is one of the most basic data collections of the village. As will be presented later, CT is composed of 8 hamlets called *xom* in Vietnamese. *Xom B* is one of the 8 *xom*. The association conducted basic data collection in *xom B* in 1995. The research covered agricultural activities, the economy, personal histories, and other kinds of research. *Xom B* had 154 household in those days, out of which 113 household answered our questionnaires. The percentage of replies was 73 % of the total households in *xom B*. The results of the *xom B* basic data collection is shown in *Thong Tin Bach Coc* (Sakurai 1996: 1-114).

In addition, the author visited the village on several occasions between 1994 and 1998 and collected information through participatory surveys and interviews with the administrators of the cooperative and farmers as well. The author also conducted research to record agricultural practices in 1998. The results will be shown in Chapters 3, 4, 5, and 6. Furthermore, soil analysis was carried out after sampling of the soils in the representative land units. The results of the soil analysis will be shown in Chapter 2 and 3.

Chapter 2. Outline of the Coc Thanh Cooperative

2.1. The Red River Delta

2.1.1. The Red River

The Red River, which makes up the Red River Delta, is one of the greatest rivers in Southeast Asia. It rises out of the mountainous area of Yunnan Province in China. It is 1,146 km long, out of which 550 km is in Vietnamese territory (Dieu 1995). The mean discharge of the river is estimated to be 4,100 m^3/s (Binnie and Partners 1995). The name of the Red River comes from the color of the river, which is extremely red. As is understandable from the color of the water, the river contains a large quantity of sediment. The mean concentration of the suspended sediment in the Red River at Hanoi is estimated to be 850 mg/l (Binnie and Partners 1995). The large quantity of sediment is still making the area of the delta wider year by year. The high speed of accretion, which reaches 80 - 100 meter/year can be observed in the coastal area from Kim Son to Nga Son in the southeastern part of the delta (Phai 1999).

2.1.2. The Red River Delta

After the Red River flows down through the mountainous areas of China and Vietnam, it creates a delta whose vertex is at Viet Tri, which is the Red River Delta (Fig. 2-1). Although the delta, strictly speaking, consists of the Red River system mentioned above and the Thai Binh system, which flows in the northwest part of the Red River, most of the deltaic area, including the lowland area of this study, is covered by the delta of the Red

River system.

According to the statistics of 1994, the Red River Delta is composed of 9 provinces, which are Ha Nôi, Hai Phong, Ha Tay, Hai Duong, Hung Yen, Ha Nam, Nam Dinh, Thai Binh, and Nin Binh, with a total area of 11,270 km^2 (General statistical office 1995). The actual area of the delta is, however, estimated to be 16,644 km^2, because it covers some areas at the foot of the mountains and hills in the north and southwest (Binnie and Partners 1995).

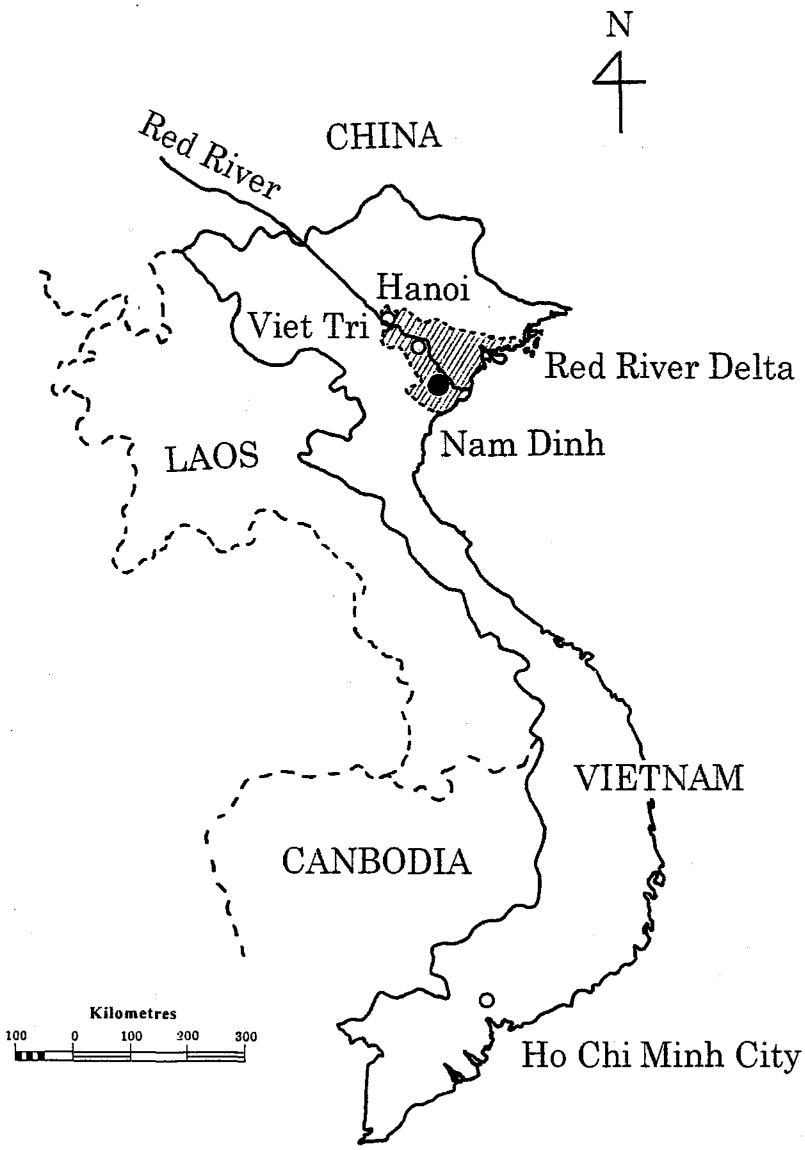

Fig. 2-1. Location of the Red River Delta

In terms of rice production, another distinctive feature of the Red River Delta in comparison with the other Southeast Asian deltas is the rice cultivation techniques (Sakurai 1987, *ibid.* 1992). According to a classification by Takaya (Takaya 1987), the other Southeast Asian deltas have been reclaimed for the floating-rice type of rice-cultivation techniques, although the Red River Delta has been reclaimed for the East-Asian type of rice-cultivation techniques, which is called the "Irrigation-transplanting type."

The floating-rice type developed in deltaic areas in a monsoon climate in which the dry and rainy seasons are clearly different. Rice is not cultivated in the dry season due to a shortage of irrigation water. The rainfall at the beginning of the rainy season enables farmers to plow, harrow, and sow rice seeds, but not transplant rice seedlings. During the rainy season, the paddy is flooded over the top of the rice plant, and harvested after the flood water subsides. In areas with irrigation-transplanting type of rice cultivation techniques, on the other hand, the paddy is irrigated by a irrigation canal to prepare the paddy for the transplant of rice seedlings.

Although the floating-rice type of rice-cultivation techniques was often seen in the Chaophraya delta of Thailand until the 1960s, the irrigation-transplanting type of rice cultivation techniques has been conducted in the Red River delta for several hundred years as the embankments and canals were, at the latest, constructed in the 13^{th} century (Yanagisawa et al. 1996). At present, the whole deltaic area has an under irrigation and drainage system (Fig. 2-2). According to Fig.2-2, the Red River Delta at present is divided into 30 irrigation schemes. Each scheme has one or several irrigation companies to control the irrigation and drainage system in the scheme.

The village in this study belongs to the Bac Nam Ha irrigation scheme in Fig. 2-2. The name is not commonly used in the local area. The irrigation company managing the system in this area is called Nam Ha Irrigation Company (*Cong Ty Quan Ly Khai Thac Cong Trinh Thuy Loi 1 - Nam Ha*, hereafter called the Nam Ha Irrigation Company), because it was named after the old name of province. There is, however, no province named Nam Ha at present. It was divided into two provinces, Nam Dinh and Ha Nam. The author, therefore, calls this area the Nam Dinh Polder because the center of the area is Nam Dinh City, which is the third biggest city in the Red River Delta, and it is surrounded by big four rivers such as a polder.

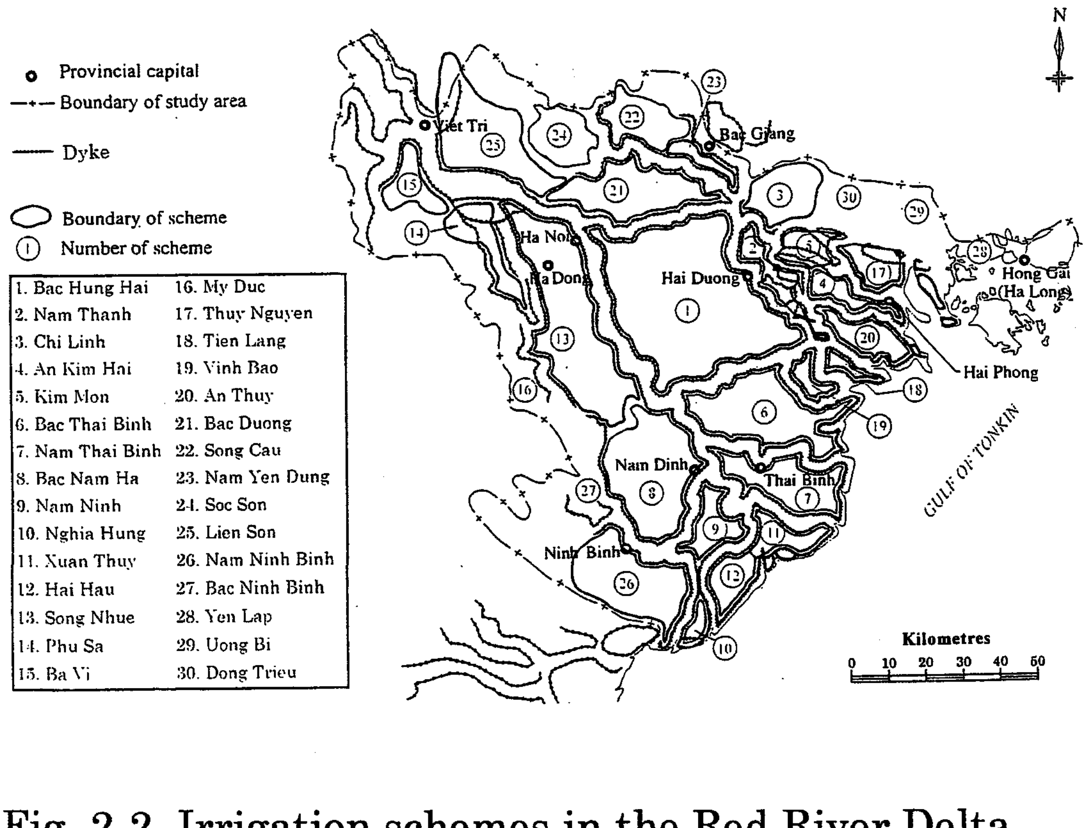

Fig. 2-2. Irrigation schemes in the Red River Delta

Source: This map originated from Binnie and partners (1995)

2.2. The Nam Dinh Polder[1]

Nam Dinh Polder is located in both the Nam Dinh and Ha Nam Provinces and has a total command area of 85,326 ha, being one of the biggest schemes in the Red River Delta (Fig.2-3). The area is surrounded by four rivers, namely, the Red River at the northeast, the Dao (Nam Dinh) River at the southeast, the Day River at the west, and the Chau Giang River at the north. This is also a part of the lowest area of the Red River Delta. More than half of the area is lowland with an elevation of less than 1.25 m above mean sea level, while the water level of the surrounding rivers reaches more than 3 m in summer.

Its topography is a complex of natural levees and backswamps in the upper reaches and of sand ridges and lagoons downstream. CT is located at the boundary between the backswamps and sand ridges.

Due to being a lowland area, people in the Nam Dinh Polder began constructing partial embankments along the rivers in the 13th century. Those polders were connected to each other and created a circle of embankments during the French period at the latest.

Although the construction of a polder system protected it from water intrusion from the outer big-rivers in the summer season, drainage from the inside polder conversely became difficult. The lowland areas of the polder were not used as fields, but as retarding basins. Even in most of the paddies, rice production was limited to only in the spring season.

Although the embankments were reinforced, dike breaks and overflow from surrounding rivers still has frequently occurred in the area, causing severe damage not only to rice cultivation but also to human settlements and the public infrastructure in 1985 and 1994 in recent times.

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[1] This section is mainly based on Kono and Yanagisawa (1996).

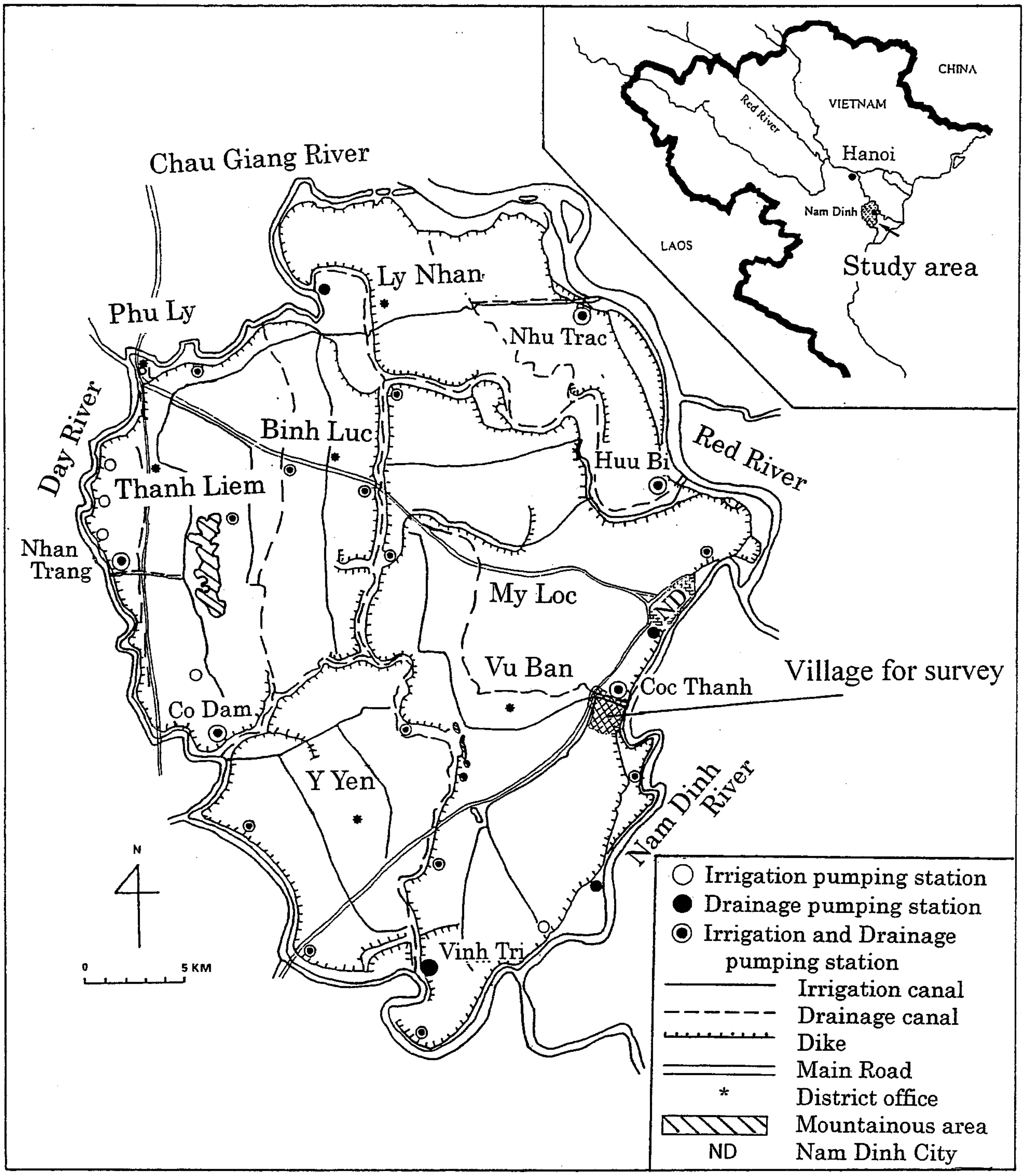

Fig. 2-3. Nam Dinh Polder and the Coc Thanh Cooperative

Before the 1960s, there were no irrigation and drainage facilities other than the river embankments and water gates along the surrounding rivers, which were constructed during the French period. Rice was grown in spring under rainfed conditions. In summer, most of the area was covered with deep water, except for hamlet areas located in higher elevations, and there was little paddy cultivation. Boats were the major means of transportation during this season.

Since the 1960s, the government has constructed, at first, six large-scale, and later, medium and small scale pumping stations along the surrounding rivers, and canal systems for the irrigation and drainage spreading from the pumping stations. The large scale pumping stations with a total capacity of 235 m^3/sec were constructed between 1968 and 1972, and land consolidation in the following period expanded the rice planted area in the summer season as well as in the spring season, stabilizing rice yields and intensified cropping patterns.

Nevertheless, it was quite difficult to manage irrigation and drainage in such a huge area with uneven land. Twenty percent of the total area has an elevation of less than 0.8 meter above sea level, where rice could not be cultivated in summer due to deep water. Even in most of the paddies over 0.8 meter above sea level, the rice yield in the summer season was not stable due to the flooding which occurred frequently.

Middle and small scale pumping stations were, therefore, constructed after the large pumping-station system had been established. Village-level irrigation and drainage facilities have rapidly been developed since the mid-1980s, when *doi moi* (renovation policy, see section 2.5) started. This is clearly reflected in the construction of pumping stations (Fig.2-4). Moreover, lifting devices, canal systems and embankments for flood protection have been improved and constructed at the village level.

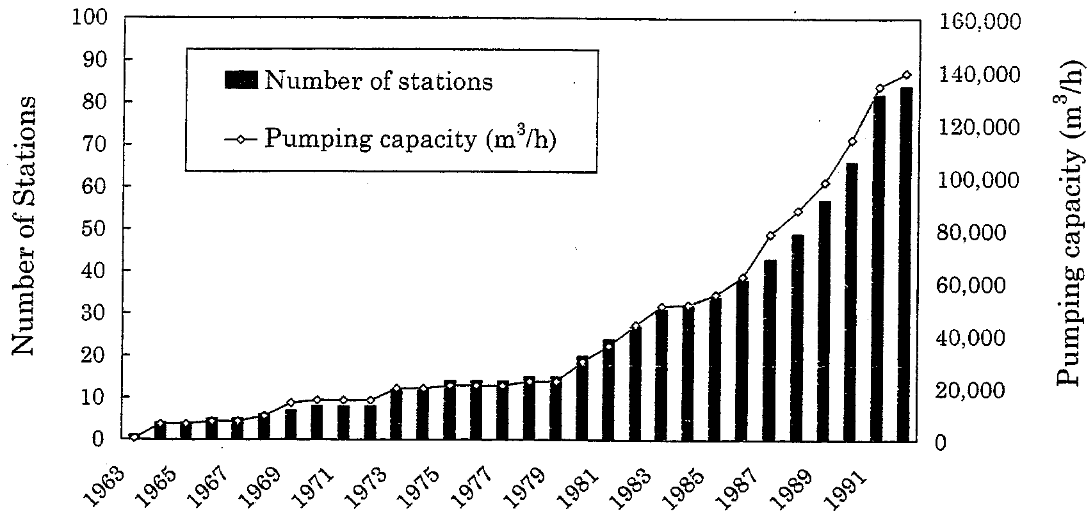

Fig. 2-4. Increase of cooperative-managed pumping stations in Vu Ban district

Source: The Vu Ban District Branch of the Nam Ha Irrigation Company

The present pumping capacity per unit area of the sampled 18 villages which the authors visited in 1996 was 4.0 liter/sec/ha for irrigation and 2.6 liter/sec/ha for drainage on average. This irrigation capacity is enough for rice cultivation if a stable water supply is available. The drainage capacity is, however, too small to cope with heavy rainfall, reflecting the difficulty of solving drainage problems at the village level.

The large scale pumps are, at present, operated based on the water level of the main drainage canals at the pumping stations. Irrigation is carried out if the water level is less than the standard level, and drainage is carried out if it is more than the standard. The standard water level is, in most cases, 1.2 m in winter-spring and 0.8 m in summer. Two factors were considered in determining the standard water level. One is the balance between water deficit in higher paddies and the water excess in lower paddies, and the other is the capacity of the drainage canals and pumping efficiency. When a typhoon or heavy rainfall is predicted, precautionary drainage is carried out in the lower water levels. The present pumping capacity is 2.9 liter/sec/ha for drainage and 0.81 liter/sec/ha for irrigation.

2.3. The Coc Thanh Cooperative

2.3.1. Location

CT belongs to the Thanh Loi commune in the Vu Ban district of Nam Dinh province, lying about 60 km southeast of Hanoi, the capital of Vietnam, and 7 km southwest of Nam Dinh, the third biggest city in the Red River Delta.

2.3.2. Population, area, and population density

The population of CT in 1997 was 3,742, the total surface area covered 385 ha, and the population density was 972 person/km^2. Of the total population, 98% belonged to agricultural households. The main economic activity of CT was agriculture, and only a few subsidiary enterprises existed. The number of households was 1,097, and the total cultivated area was 253 ha; thus the cultivated area per household was 0.23 ha, and the cultivated area per capita was 0.06 ha on average.

2.3.3. Agricultural land

According to the *Xom B* basic data, the average area of agricultural land per one person living in *xom B* in 1995 was 527 m^2 (Table 2-1). In the table, paddy is an area with double cropping of rice, and upland is an area planted with upland crops in the spring season. In the land classification in Chapter 3, the areas of double cropping of rice and of winter crops plus double cropping of rice correspond to paddy areas, and the other areas to upland areas. Pond means a pond near residences.

Table 2-1 shows that, out of the average area of agricultural land per person (527 m^2), the paddy area was 406 m^2, the upland area was 109 m^2, and the pond area was 13 m^2. The maximum paddy areas was 1,302 m^2, and the minimum 167 m^2, which is a difference of 7.8 times. The maximum upland areas was 552 m^2, and the minimum 24 m^2, a difference of 23 times. The distribution of paddy area per household is shown in Fig. 2-5.

Table 2-1. Agricultural land per person by landuse

	Paddy	Upland	Pond	Total
Average	406	109	13	527
Maximum	1,302	552	300	1,854
Minimum	167	24	0	218

Unit: m^2/person

Source: *Xom B* basic data in 1995

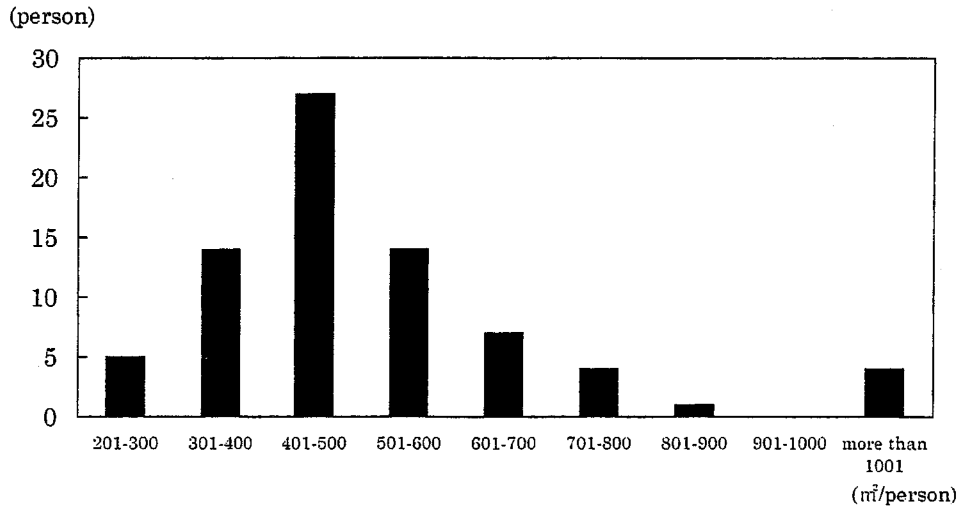

Fig. 2-5. Distribution of paddy area per person in *xom B*

Source: *xom B* basic data (Sakurai, Y. 1996)

In parallel with the governmental policy of promoting economic renovation and allocating land to individual farmers (see section 2.5), land was allocated to the CT farmers in 1992 and 1994. The landuse rights were distributed equally to all the members of the commune who hoped to get land. Land allocation in 1994 was conducted to correct a mistake and inequalities at the first allocation in 1992.

As shown in Fig. 2-5, however, the paddy area per person was not equal. The biggest difference was 7.8 times. According to the executive staff of the cooperative, this is because there is no adjustment for members who had died and moved both in and out of the commune. It is, however, hard to believe that a difference of 7.8 times could have occurred within three years after the land allocation. It may be because landuse right is not only inherited and given, but also sold and bought.

2.3.4. Irrigation system

The Coc Thanh Pumping Station, adjacent to CT, is one of the large-scale pumping stations constructed in the late 1960s. It has 7 electric pumps made in the Soviet Union, which enable an area of 12,221 ha to be irrigated and 19,863 ha to be drained.

The location adjacent to the Coc Thanh Pumping Station makes CT's water management easy because the pumping station is located at the uppermost part of the irrigation canal, and at the nearest part from the drainage point. Although irrigation and drainage from the main canal is, of course, determined by the Nam Ha Irrigation Company, the location of CT is of great advantage for water management.

2.3.5. Organization

In general, the cooperative in this area was established in 1959, after the establishment of mutual labor groups (*to doi cong*). CT, at first, formed their own cooperatives from eight hamlets (*xom*). After some consolidation and abolition of these eight hamlets, they formed the present cooperative in 1980, and the hamlet was administratively called the brigade (*doi*).

The number of regular staff who manage the cooperative's activities and draw salaries from the cooperative is 27, of whom 6 are executive staff, 5 normal staff, and 16 the head and secretary from each of the eight brigades in the cooperative. In the following description, "CT" means the Coc Thanh cooperative as an administrative unit, and "the cooperative" means the group of 27 staff members of the Coc Thanh cooperative who manage CT.

2.4. Climatic conditions

Figure 4-2 in Chapter 4 shows the monthly rainfall and air temperatures recorded at the Nam Dinh Meteorological Station, 7 km from CT, from 1986-1995. Average annual rainfall was 1,610 mm, 90 percent of which fell from May to October, which is summer there. There was a large variation between years, however, from a high of 3,005 mm in 1994 to a low of 977 mm in 1988. The average air temperature was high from May to September, and the average monthly temperature during this period was above 27 °C. In other months, it seldom exceeded 24 °C. From December to February, the weather was cold and the minimum temperature was sometimes lower than 5 °C. When spring rice seedlings are exposed to an extended cold spell, they can be damaged and the harvest is likely to be considerably reduced.

The period from December to February is a season of drizzling rain called *mua phun* in Vietnamese. The weather can be continuously cloudy for several weeks, and solar radiation is very low.

2.5. Changes in institutional settings after *doi moi*

After the introduction of a series of renovation policies started in 1986 (*doi moi* in Vietnamese) which converted the economy toward a market mechanism operation, it is well-known that Vietnamese agriculture has markedly changed. In particular, Resolution 10 on the renovation of agricultural management promulgated on 5 April 1988 can be considered to be a turning point in agricultural policy (Murano 1989). Resolution 10 stipulated that a "contract system" should be implemented which would deal with all peasant households, and their cooperative land should be assigned to farming households for long-term use of 10 to 15 years in the form of contracts or bidding (Cuc 1995). Furthermore, Resolution 5 promulgated in June 1993 and the Land law issued in July 1993 extended land users' rights and secured farmers' investment in land improvement in order to increase the number of seasonal crops (Iwai 1996, Land Law 1995). In the past, farmers belonged to a group farming system managed by the cooperatives and were not allowed to select the crops themselves, which may account for the fact that agricultural productivity failed to increase. It should, however, be stated that the above-mentioned agricultural reform policy, that is, transition to privatization and a market economy, gave farmers high incentives to produce and a widen market to sell and buy their agricultural products and, as a result, agricultural productivity markedly increased and farming systems were remarkably intensified and diversified.

Chapter 3. Land classification by changes in cropping patterns

3.1. Introduction

For the purpose of understanding all the cropping systems in CT, agricultural land was divided into 8 Types on the basis of the present and past cropping systems, and the historical changes. To analyze cropping systems between pre and post *doi moi* is, in another words, to consider the historical background of cropping systems. This will make it easy for us to understand the effect of natural and socio-economic factors on the cropping systems in CT.

In this chapter, the cropping systems in the 8 types of land classification are described, and the factors of the physical conditions and cultivation techniques of the present and past cropping systems and the historical changes are discussed.

3.2. Research method

Besides the data collected through participatory surveys and interviews and soil samples of the representative land units, the author got data on the cropping systems for several years in CT, which had been recorded by the executive staff of the cooperative. In the discussion on analyzing the changes in the cropping patterns, the author used the year of 1985 as the base line year for cropping patterns before *doi moi* for the following reasons: (1) farmers recalled this year very clearly as the last year before changes started and, (2) land registers of those days made by CT were available to estimate the crop planted areas (Coc Thanh Cooperative 1992a, 1992b).

3.3. Changes in cropping patterns

Land elevation in CT is an important factor in the selection of the cropping patterns. Local farmers classify land into 6 levels, in the order of land elevation; *cao, van cao, van, vua phai, thap,* and *trung,* which mean the highest, rather high, high, moderate, low, and low-lying marshy land, respectively. Correspondence between local classification and type of the changes in the cropping patterns is shown in Table 3-1 and explained in the following section.

Table 3-1. Characteristics of soil conditions and land elevation by Types[1)]

Type[2)]	Samples[3)]	Elevation[4)] (cm)	Local classification	pH	TC[5)] (%)	Avai N[6)] (mg/100g)	Avai P[7)] (mg/100g)	Ex-K[8)] (mg/100g)	CEC[9)] (me/100g)	Clay[10)] (%)
1, 2	18	205	*cao. van cao*	5.8	1.2	1.6	18.8	4.5	7.6	25.6
3	12	180	*van*	5.9	1.4	2.7	15.1	4.0	7.8	26.1
4	2	140	*vua phai*	5.6	1.9	2.8	14.1	4.8	8.7	35.0
5	5	144	*vua phai*	5.7	1.9	5.7	16.3	6.3	7.8	30.2
6	8	142	*vua phai*	5.9	1.3	2.8	17.2	3.9	8.9	26.1
7	7	133	*vua phai*	5.4	2.2	8.9	10.8	4.4	9.0	32.6
8	121	105	*thap*	5.3	2.8	8.2	13.8	5.5	10.1	38.7
Average	173	122		5.4	2.4	6.8	14.5	5.2	9.5	35.3

Note; 1) 174 soil samples were collected in the Coc Thanh cooperative in 1996. All the soil samples were analysed in the Vietnam Agricultural Science Institute in Hanoi.

2) Data of Types 1 and 2 are shown in one category because the fields in Types 1 and 2 were mixed and could not be separated. The fields in Type 1 are rather closer to farm houses than those of Type 2.

3) One sample taken from a field along the Nam Dinh river is not included.

4) This figure is the average of the soil-sampling points.

5) TC; Total organic carbon (as percentage of air-dry soil)

6) AvaiN; Ammoniacal nitrogen production (in mg NH_3-N/100 g air-dry soil)

7) AvaiP; Available phosphorus (in mg P_2O_5/100 g air-dry soil)

8) Ex-K; Exchangeabel potassium (in mg/100 g air-dry soil)

9) CEC; Cation exchange capacity (in me/100 g air-dry soil)

10) Clay; Clay content (in percentage)

3.3.1. Cropping patterns in 1985

Cropping patterns in 1985 were classified into four types, that is, vegetable cropping throughout the year (VEG), groundnuts in the spring season and rice in the summer season (GN-RR), nursery beds both in the spring and summer seasons (NB), and double cropping of rice (SR-RR) (Fig. 3-1). The seasonal changes in distribution of crops planted in 1985 is shown in Fig. 3-2.

Cropping pattern	Cropping calendar												Planted area (ha)	Percent (%)
	J	F	M	A	M	J	J	A	S	O	N	D		
VEG													2.7	1.3
GN-RR													25.6	12.5
NB													17.8	8.7
SR-RR													158.2	77.5

Fig. 3-1. Cropping patterns and planted area in 1985

Notes; VEG: vegetables, GN: groundnuts, RR: summer rice (rainy season rice), SR: spring rice, NB: nursery beds

Source; This figure is estimated from the land register of CT and results of interviews with farmers in 1995 and 1996.

As shown in Fig. 3-1, the area under VEG covered 2.7 ha and vegetables were planted throughout the year in home gardens or fields at a higher elevation near the farm houses. In the summer season, herb crops such as coriander (*Coriandrum sativum*) and leafy vegetables like water convolvulus (*Ipomoea aquatica*) and Tossa Jute (*Corchorus olitorius* L., *rau day* or *day qua dai* in Vietnamese) were planted. In the winter to spring season, Irish

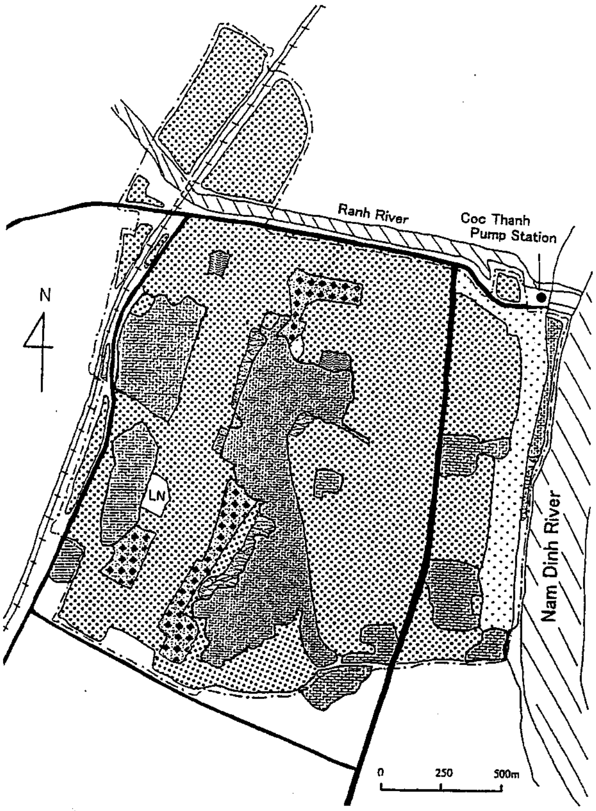

Fig. 3-2a. Summer season (June-September)

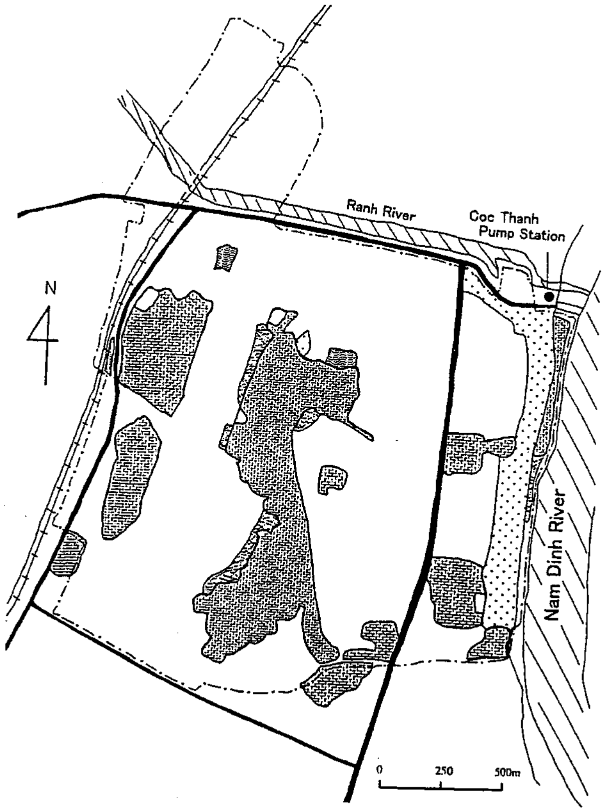

Fig. 3-2b. Winter season (October-December)

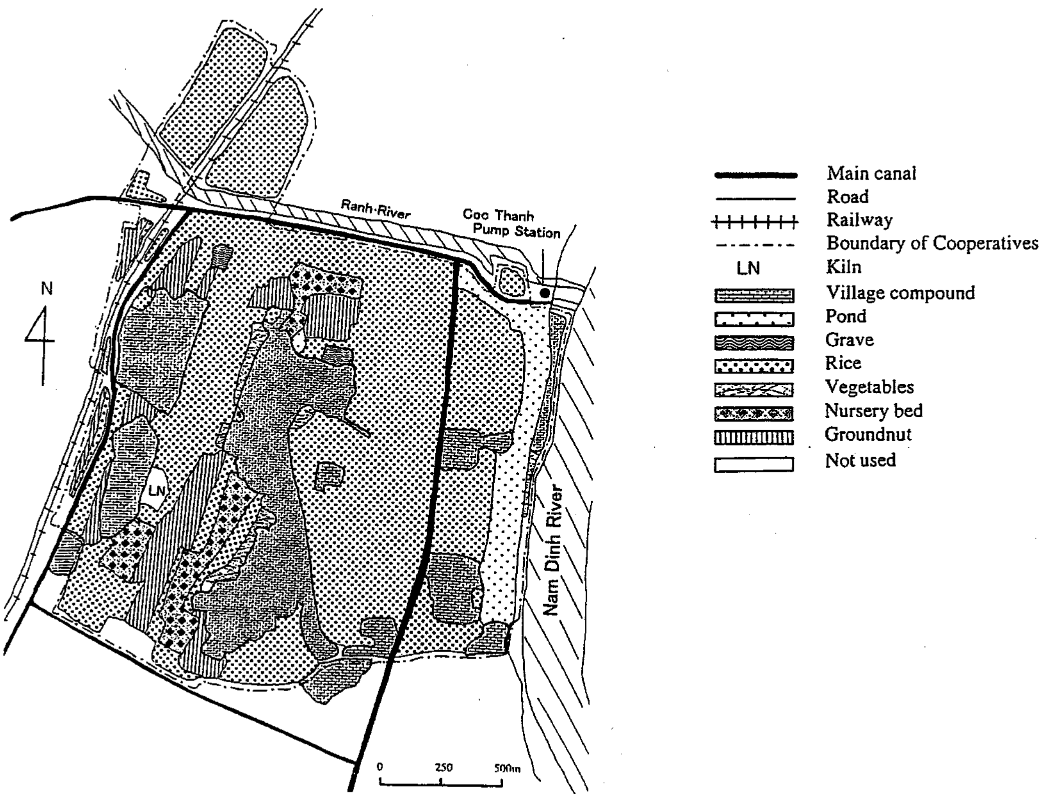

Fig. 3-2c. Spring season (January-May)

Fig. 3-2. Landuse of CT in 1985

potato (*Solanum tuberosum*), kohlrabi (*Brassica oleracea* var. *gongylodes*), and leafy vegetables such as stem lettuce (*Lactuca sativum* var. *asparagina*), Chinese radish (*Raphanus sativum*), cos lettuce (*Lactuca sativum* var. *longifeolia*), garland chrysanthemum (*Chrysanthemum coronarium*), ceylon spinach (*Basella rubra*) and other kinds of vegetables were planted. Vegetables, however, were planted only over small areas and used primarily for home consumption. The area under GN-RR covered 25.6 ha. In those days, groundnuts had to be planted under contract of the Government in the spring season. CT assigned 25.6 ha of the higher elevation fields to groundnut production. Farmers supplied 30-40kg/*sao* (*sao* is 360 m^2, 0.83-1.1ton/ha) of the harvest to the Government and used the remaining part for their own purposes. In the GN-RR fields, farmers planted rice in the summer season (or rainy season rice, *lua vu mua* in Vietnamese). Rice was sown in June in nursery beds which were irrigated by the Coc Thanh Pumping Station, transplanted in July and harvested in October-November.

The area under NB covered 17.8 ha. It was selected according to the elevation, proximity to houses, ease of irrigation and drainage, and the soil characteristics (not acidic). This area was used only for nurseries and not for growing any crops at all, from the time of pulling of the seedlings until sowing of the seeds of the next crop.

The area under SR-RR covered 158.2 ha. The spring rice (*lua vu chiem*, in Vietnamese) was sown in January, transplanted in February and harvested in June, and after that the summer rice was planted. In the winter season after the harvest of the summer rice, more than 90 % of the cultivated area was not utilized except for vegetables planted in home gardens and higher elevation fields near the farm houses.

Cropping intensity (Gross cropped area / net cropped area) in 1985, therefore, was 2.11, which was estimated by the following calculation. Of the total cultivated land, 158.2 ha were used for double cropping of rice (SR-RR), 17.8 ha for nurseries twice a year (NB), 25.6 ha for GN-RR and 2.7 ha of the highest land devoted to vegetables was estimated to yield ten crops per year[1] (VEG). The total cultivated area per year was thus 430.2 ha with a cropping intensity index of 2.11 ((158.2 x 2 + 17.8 x 2 + 25.6 x 2 + 2.7 x 10) / 204.3).

3.3.2. Changes in cropping patterns from 1985 to 1996

Before 1988, farmers could not select cropping patterns freely by themselves. After the land distributions of 1988, 1992 and 1995, all the land was distributed to the farmers. Cropping patterns in the CT underwent a change because farmers were able to use their own land without any limitation due to administrative reasons.

Figure 3-3 shows the seasonal changes in crops planted in 1996. Figure 3-4 shows the cropping patterns in 1996. In terms of changes in cropping patterns from 1985 to 1996, eight types were observed (Type 1 to Type 8). Soil conditions and land elevation in these types are shown in Table 3-1 and Fig. 3-5. The changes in the cropping patterns and physical conditions were as follows:

(Types 1 & 2)

In general, in the Nam Dinh Polder, which lies in the lowest part of the Red River Delta, settlements are located in the highest part of the area. The fields in Types 1 & 2 are distributed around the settlements, where the highest part of agricultural land is located. The average height of the soil-sampling points in Types 1 & 2 is more than two meters. Farmers classify these fields as the highest (*cao, van cao*). Clay content of the fields in Types

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[1] See Chapter 5.

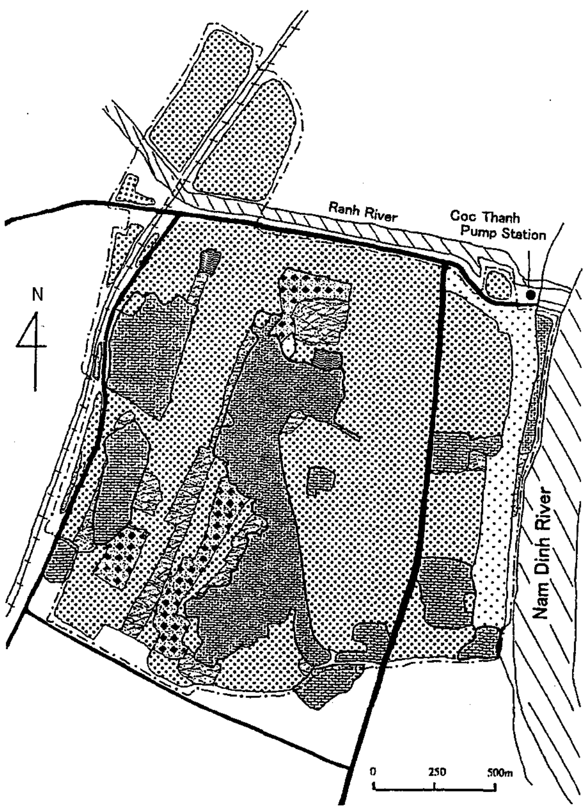


Fig. 3-3a. Summer season (June-September)

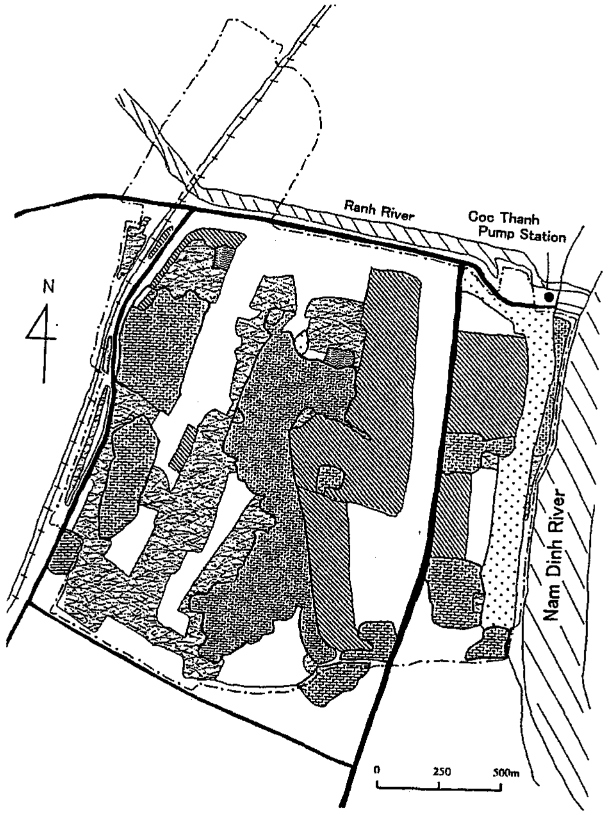


Fig. 3-3b. Winter season (October-December)

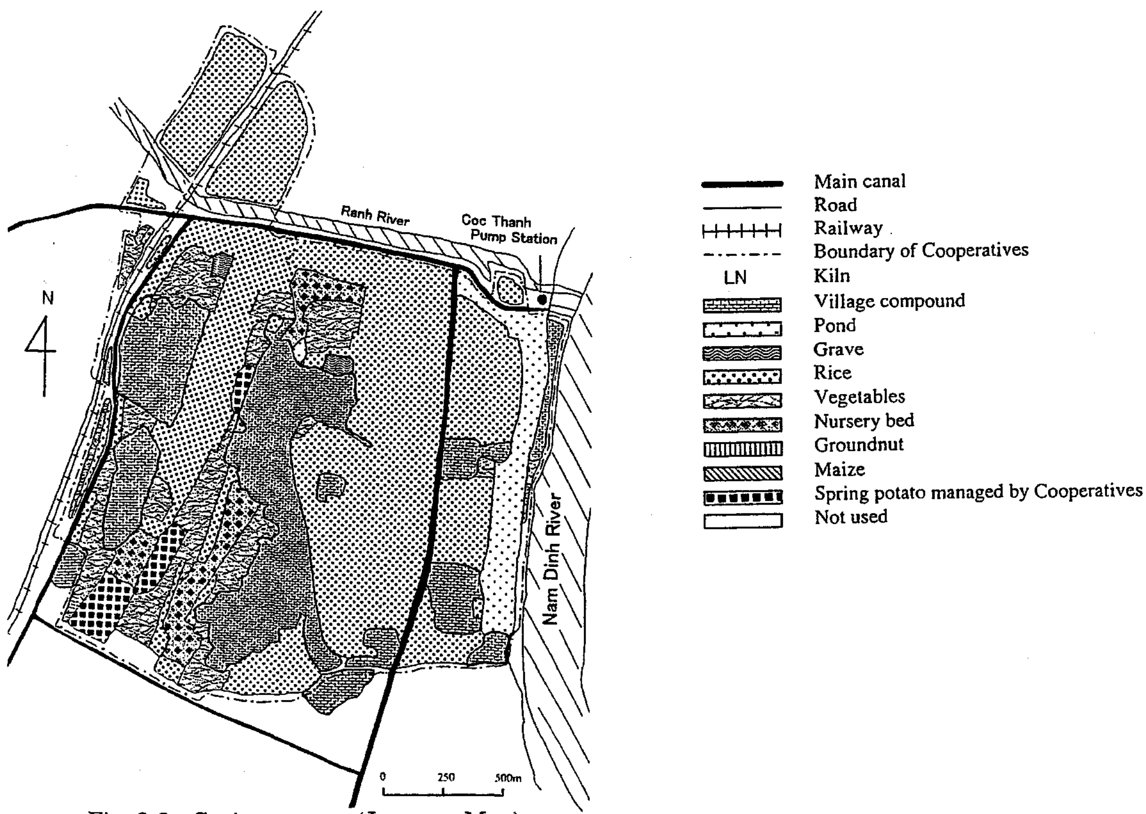


Fig. 3-3c. Spring season (January-May)

Fig. 3-3. Landuse of CT in 1996

1 & 2 is the lowest among the 8 Types and sandy soil predominates. As a result, vegetables and not rice are the main crops.

The area planted with vegetables throughout the year expanded by 4.4 times, i.e. from 2.7 ha in 1985 to 11.9 ha in 1996. This area consisted of 2 types, i.e. Type 1 (VEG → VEG) and Type 2 (GN-RR → VEG). Regarding the expansion of the area planted with vegetables, the differences between these two types were not due to the physical conditions but may be ascribed to other factors, such as low market demands and labor shortages.

Cropping pattern		Cropping calendar	Planted area	Percent	Type*
in 1985	in 1996	J F M A M J J A S O N D	(ha)	(%)	
VEG, GN-RR	VEG		11.9	6.0	1, 2
GN-RR	VEG-RR		14.7	7.5	3
SR-RR	VEG-RR		0.7	0.4	4
GN-RR, SR-RR	COOP		8.3	4.2	5
SR-RR	SR-RR-VEG		9.6	4.9	6
NB	NB-SR-NB-RR		10.9	5.5	7
SR-RR	SR-RR		141.0	71.5	8

Fig. 3-4. Cropping patterns and planted area in 1996

Notes; VEG: vegetables, GN: groundnuts, RR: summer rice, COOP: fields managed by the cooperative, in which Irish potato is planted from December until February, rice in the late spring, rice in the summer season, and vegetables in the winter season, SR: spring rice, NB: nursery beds

* Classification based on changes in cropping patterns from 1985 to 1996. See the text in detail.

Source: This figure is estimated from the land register of the Coc Thanh cooperative and results of interviews with farmers in 1995 and 1996.

Many vegetables, such as welsh onion (*Allium fistulosum*), garlic (*Allium sativum*), chinese chive (*Allium tuberosum*); tomato (*Lycopersicon *esculentum*), pepper (*Capsicum annuum*), new varieties of lettuce and so on, were planted in addition to previously planted crops and used both for domestic consumption and for selling at markets. Vegetables were also

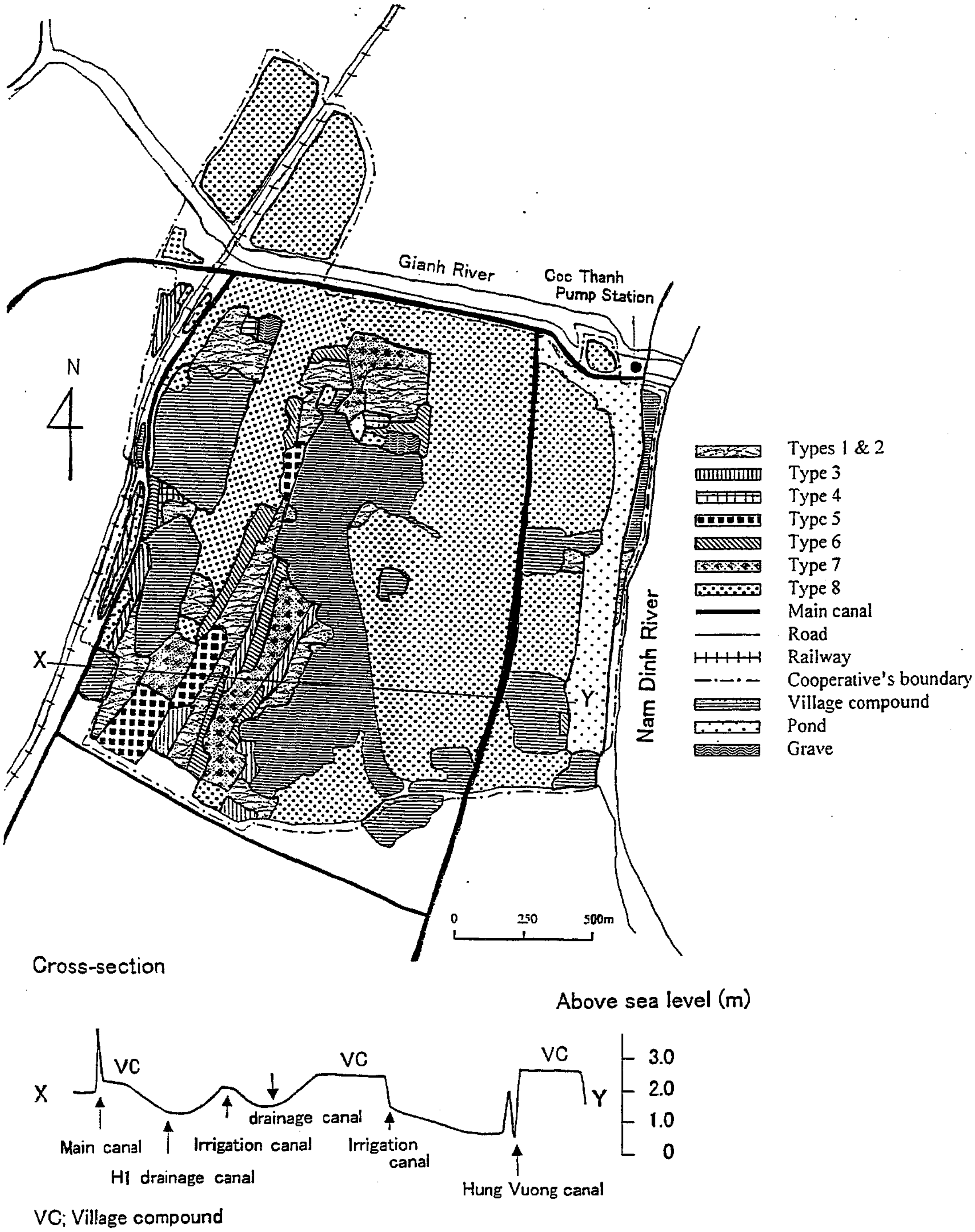


Fig. 3-5. Land classification by Types and cross-section of the land operated by CT

planted in fields in which groundnuts had been planted in 1985 because vegetable cultivation is more profitable than groundnut cultivation. Farmers use a piece of the field more than five times a year. The fields in these types are characterized by the highest farming intensity among the areas of the cooperative.

The actual situation of vegetable cultivation and an analysis of intensification will be discussed in Chapter 5.

(Type 3)

This is a buffer zone between the area of vegetable-based cropping pattern and rice-based ones.

Cropping pattern changed from groundnuts in the spring season and rice in the summer season in 1985 (GN-RR) to vegetables in the winter and spring season and rice in the summer season in 1996 (VEG-RR). Besides the vegetables planted in Types 1 & 2, Irish potato, sweet potato, and kohlrabi (*Brassica oleracea* L. var. *gongylodes*) are planted in the winter season. Mixed cropping with vegetables observed in Types 1 & 2 is also found. Tubers of Irish potato and swollen stems of kohlrabi are used both for domestic food consumption and for selling at markets. Leaves of both crops, small tubers, and small or large swollen stems of kohlrabi are used for animal feed. Tuberous roots of sweet potato are mainly used for domestic food consumption. Although leaves or small tuberous roots of sweet potato are mainly used for animal feed, people sometimes eat young leaves as vegetables.

According to the farmers, vegetables are planted in almost all the fields in this type during the winter and spring seasons, if the rainfall is not too much because the elevation is comparatively higher than that of the fields in Types 4, 5, 6, 7, and 8. They, however, plant potatoes or kohlrabi, whose growing period is longer (about three months) than that of other vegetables.

Farmers select these crops partly because of labor shortages in their own households. Sole or mixed cropping of potatoes or kohlrabi in Type 3 does not imply intensive use of land, but, rather, adaptation to changes in the climatic conditions, the labor force situation within the household, and fluctuations of the market price. The area planted with vegetables changes both with seasons in a particular year and over the years.

(Type 4)

This Type denotes areas where double cropping of rice was once implemented and then switched to the cultivation of rice in the summer season and vegetables in the other seasons. The fields in Type 4, which are surrounded by land at a relatively high elevation occupied by houses and graves, are located in undulating land. They are difficult both to drain in the summer season and to obtain water for irrigation in the winter and spring seasons. Although the cropping patterns in Type 4 were almost the same as those in Type 3, the area planted with leafy vegetables can not be expanded without improvement of the irrigation and drainage facilities.

(Type 5)

This type of cropping pattern in 1996 consisted of the cultivation of Irish potato from December until February, rice in the late spring, rice in the summer season, and vegetables in the winter season. Potato production is managed by the cooperative.

Potato cultivation as an enterprise managed by the cooperative will be discussed in Chapter 6.

(Type 6)

Cropping pattern changed from double cropping of rice in 1985 to double cropping of rice and an upland crop in the winter season, which is mainly sweet potato. According to Table 3-1, the land in this type seems to be close to that of Types 1 & 2, which are characterized by a high elevation and sandy soil. It is considered that soils of the fields in Type 6 originated from those in Types 1 & 2, because the fields in Type 6 mostly abut onto the lower part of the fields in Types 1 & 2 and samples used for soil analysis were taken from the soil surface. Even though the surface soil is sandy, sweet potatoes and not leafy vegetables are planted in the winter season and rice in the spring season, because the soil moisture content is high in these seasons.

(Type 7)

Since 1992, fields for nursery beds have been used not only as nurseries but also as paddy fields. After seedlings of the summer season rice are pulled, the nurseries are used as paddy fields. Since early maturing varieties of glutinous rice were introduced in 1992, the fields for the nursery beds have been used more efficiently. High utilization of fields for nursery beds is also observed in the spring season.

(Type 8)

Fields are located in the lowest area and it is difficult to intensify land use. Farmers are still practicing double cropping of rice a year. Regardless of the expansion of the vegetable cropping area, the rice-planted area by season increased from 184 ha in the summer season and 158 ha in the spring season in 1985 up to 192 and 168 ha in 1996, respectively due to the increase of the rice-cropping area in nursery beds. In terms of the area planted, there was little change in cropping systems, because 70 % of the total planted area was used for cultivation of double cropping of rice both in 1985 and 1996

Cropping intensity in 1996, therefore, was 2.92. This figure is based on the following calculation. Out of the total cultivated land, 141 ha were used for double-cropping of rice (Type 8), 17.8 ha for nurseries and two rice crops

(Type 7), and 10.3 ha for triple cropping (Types 4 and 6), including double cropping of rice and winter crops (Type 6) and rice in the summer season and double cropping of field crops (Type 4). Among others, 8.3 ha were under the control of the cooperative and used for a seed potato crops, double cropping of rice and winter crops in a year (Type 5), 14.7 ha were used for four crops a year with rice in the summer season and three vegetable crops from the winter to the spring season (Type 3), and 11.9 ha of the highest land devoted to vegetables was estimated to yield ten crops per year (Types 1 & 2). The total cultivated area per year thus covered 595.1 ha with a cropping intensity index of 2.92 ((141 x 2 + 17.8 x 4 + 10.3 x 3 + 8.3 x 4 + 14.7 x 4 + 11.9 x 5)/204).

The planted area was divided into 8 Types based on the analysis of the present and past cropping systems, and the historical changes (Type 1-8). Details of Types 8 and rice cultivation in Types 3, 4, 5, 6, and 7 are presented in Chapter 4, Types 1 & 2 and vegetable cultivation in Types 3, 4, 5, and 6 in Chapter 5, and Type 5 in Chapter 6, respectively.

Chapter 4. Rice production: An agroecologial analysis of the physical conditions and cultivation techniques

4.1. Introduction

Due to the construction of the large scale pumping stations and land consolidation in the Nam Dinh Polder since the late 1960s, the cultivated area of spring rice and summer rice became stable in CT. In addition, through institutional renovations including *doi moi* and a land allocation policy begun in the late 1980s, it is well known that the rice production in the Red River Delta has increased and CT is not an exception.

In this chapter, the author analyzes the determinant factors of the rice cropping system and annual changes in the rice yield of CT from the physical conditions and rice cultivation techniques. The analysis of the physical conditions focuses on the amount of annual rainfall, rainfall distribution, temperature, and sunshine duration. After that, the author describes farmer rice-cultivation techniques and considers the effect of techniques on the cropping system and the annual changes in rice yield to evaluate labor and capital intensification of rice production.

4.2. Outline of the rice production in CT

The main crop in CT is rice. The percentage of paddy field in the total area of CT in 1996 was 72 %. Besides this, the percentage of the area in which rice cultivated in spring and summer and upland crops in winter was 10 %. The area in which rice was cultivated in summer, and upland crops was in spring and winter, was 24 %. The percentage of the area in which nursery beds were made and rice was grown twice a year was 11 %. As a result, the percentage of the total area in which rice was planted at least once a year was 88 %.

The annual change in rice production from 1989 to 1997 in CT is shown in Fig. 4-1. The average production of rice during 9 years was 1,615 tons of unhulled rice. This value divided by the population of CT in 1997 makes annual rice production per person a year, 432 kg/person.

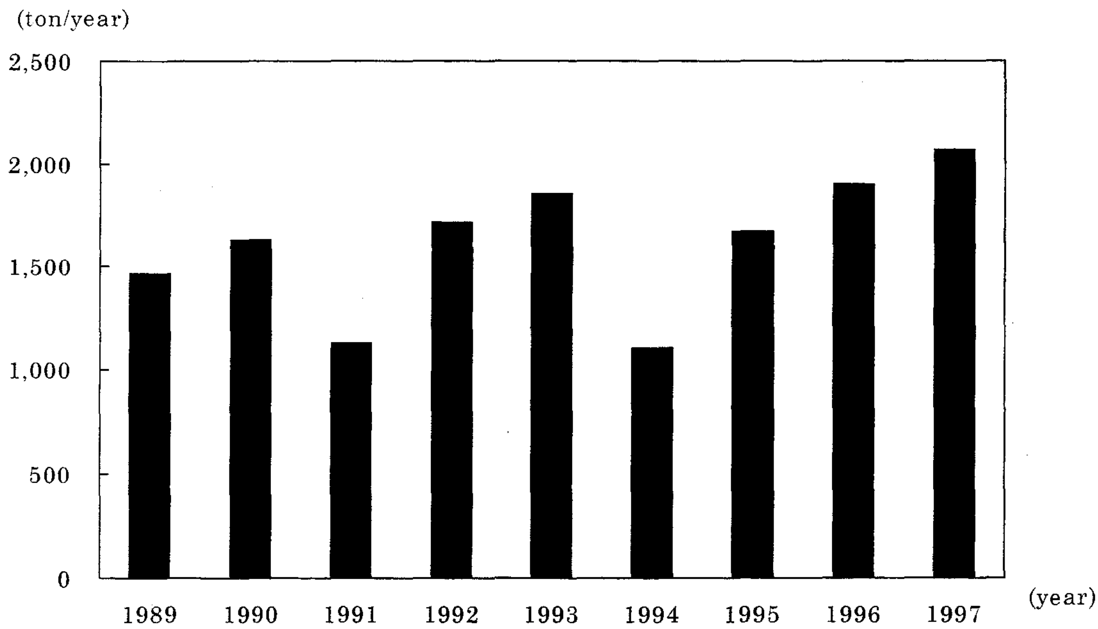


Fig. 4-1 Total rice production in CT from 1989 to 1997

Source: Interview record

According to the executive staff of the cooperative, farmers seldom purchase rice for home consumption in usual years. The results of *xom* B basic data analysis showed, however, that, out of 111 households who replied to the survey, 72 households purchased rice for home consumption. Thirty nine households did not purchased it. The total amount of rice purchased by 72 households was 13.5 tons. Supposing that the percentage of rice-purchasing households in the other *xom* was the same as that of *xom B*, 455 tons of rice was purchased as a whole in CT in 1994.

Out of 81 households, there was one household who sold their rice in 1994. The amount of rice for sale was 100 kg from the summer rice and 200 kg from the spring rice in 1995. If the amount of spring rice for sale in 1994 was the same as that of 1995, that household sold 300 kg of rice in one year. 4 tons of rice were sold as a whole in CT.

As shown in Fig. 4-1, rice production in 1994 was much lower than average because of flood damage in summer. This was the reason why people in CT purchased rice in 1994, but did not purchase it in usual years. In the year of poor yield, CT purchased 455 tons of rice from the outside and sold 4 tons to the outside. The balance was 451 tons of rice purchased.

Rice production in 1994 was 1,103 tons. Therefore, the total amount of rice consumed in 1994 was 1,554 tons, which was close to the average rice production during 9 years since 1989 until 1997.

What does this mean? Rice in CT was mainly used for eating by the people, for feed for animal husbandry, and for processing to alcohol and rice cakes. The rice purchased in a year of a seriously poor-harvest must have been purchased for essential purposes, and there was no speculative trading of rice in CT. It can be considered that purchase of rice in 1994 was to supplement the insufficiency of rice for home consumption. In CT in recent years, rice has been cultivated for home consumption. The annual consumption of rice, including for eating by the people and for feed for animal husbandry, was approximately 1,600 ton/year in the whole of CT and was 428 kg of unhulled rice per person.

4.3. Rice production and physical conditions

4.3.1. Effects of physical conditions on rice cropping patterns

As discussed in Chapter 3, there are two rice-cultivation periods in CT, one is spring and the other is summer. Spring rice is sown in December-January, transplanted in February, and harvested in June. Summer rice is sown in June, transplanted in July, and harvested in October-November. There is no other period of rice cultivation in CT. In this section, physical conditions, especially the rainfall distribution, temperature, and sunshine duration, are analyzed as determinant factors of the rice cropping patterns.

The following meteorological data was obtained from the Nam Dinh Meteorological Station in Nam Dinh City, which is 7 km northeast of CT. Data for 10 years from 1986 to 1995, including daily rainfall, temperature, and sunshine duration was analyzed. Figure 4-2 shows the monthly rainfall, temperature and sunshine duration at Nam Dinh. Rainfall data are the mean monthly rainfall for 10 years. Data of temperature and sunshine duration are the moving average of daily data for 10 years.

As mentioned in Chapter 2, the average annual rainfall is 1,610 mm. The variation between years is great, from a high of 3,005 mm in 1994 to a low of 977 mm in 1988. The rainy season is from May to October, which has 90 percent of the total rainfall a year. The period from November to April is a season with little rain and can be called the "dry season." The rainy season starts from the beginning of May. This is a typical monsoon climate according to rainfall distribution.

Farmers in CT, however, do not always start transplanting when the first rainfall of the rainy season comes. The beginning of transplanting is closely related to the pumping operation of the Coc Thanh Pumping Station, which is adjacent to CT. The Coc Thanh Pumping Station irrigates several times from May to June for land preparation, making nursery beds, and transplanting in the area. Agricultural calendar of CT is closely related to the operation of the pumping station because they use irrigation water from the main canal during the operation.

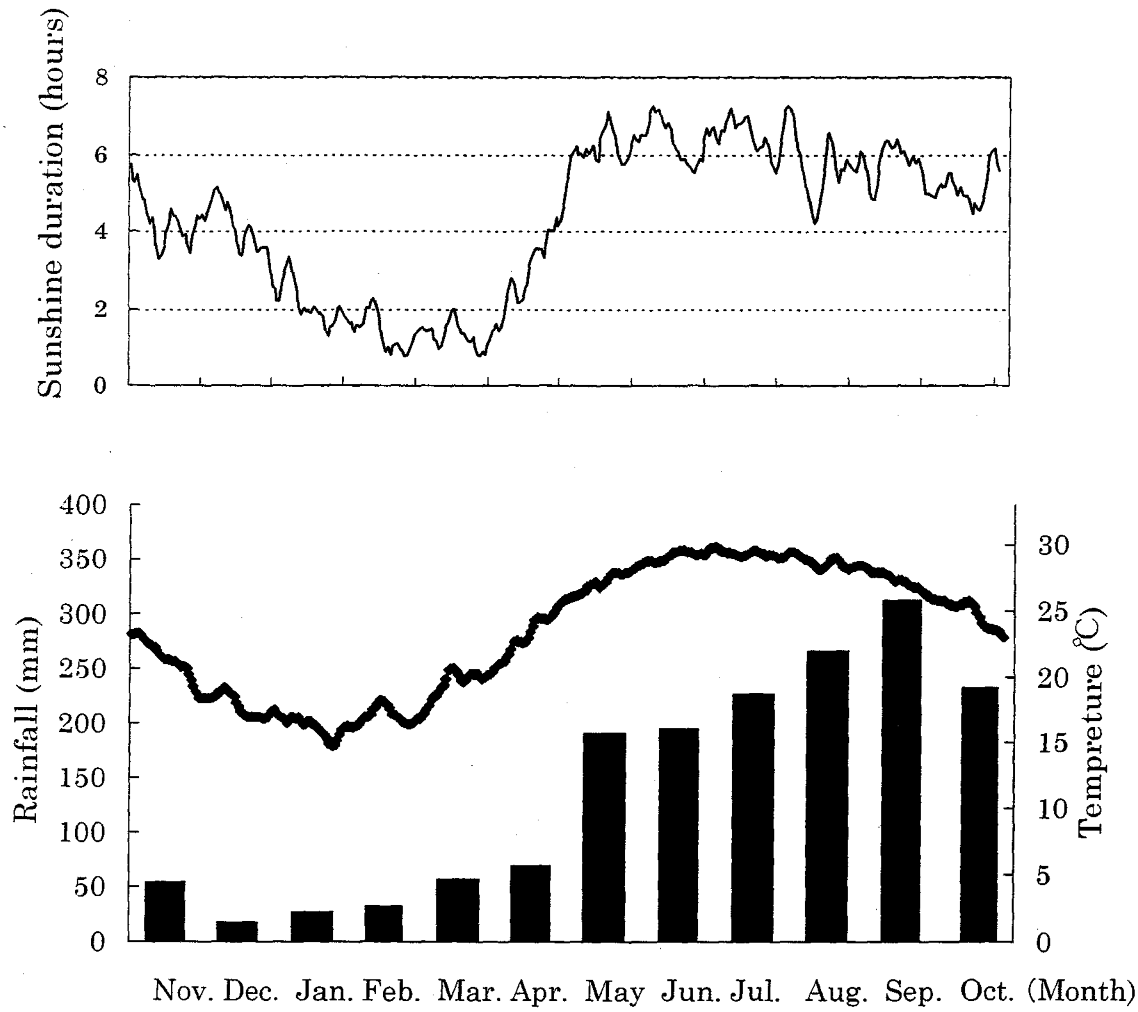


Fig. 4-2. Mean rainfall, temperature, and sunshine duration from 1982 to 1997

Source: This was modified by the figure of Kotera (1996) by adding the data of Nam Dinh Meteorological Station.

The cropping pattern of spring rice in CT is also related to the pumping operation by the Coc Thanh Pumping Station. Spring rice is usually transplanted in February, one of the least rainfall months. It is quite difficult to cultivate rice without the irrigation supplied by the pumping station.

Although operation by the Coc Thanh Pumping Station is complementary to rainfall distribution, it, in principle, determines the optimum cropping systems in the area. As a result, rainfall distribution is not directly related to rice cropping patterns both in spring and summer.

The temperature in summer in Nam Dinh is high. The average monthly temperature from May to September is above 27 °C. On the other hand, the weather from December to February is cold and the minimum temperature is sometimes lower than 5 °C. In other months, it seldom exceeds 24 °C.

Sunshine duration is long in summer and extremely short from winter to spring. Actually, we can observe thick clouds in the sky, which cover the Red River Delta for a long time during winter and spring. The ten year average of sunshine duration shows that there were days when the sunshine duration was less than 2 hours in February and March.

How do temperature and sunshine duration effect rice cropping patterns? A rice-growing model can estimate an answer to this question. Kotera (1996) evaluated rice cultivation techniques by using a rice-growing model based on temperature and sunshine duration. He used data of IR 36 as a parameter for the model. Although IR36 was a photosensitive variety for irrigated paddy fields and was not a variety widespread in the Red River Delta, many improved varieties from IRRI have been cultivated in Vietnam, and an analysis by the rice-growing model can be a way to estimate the effect of the climatic conditions, including temperature and sunshine duration on rice production in the Red River Delta.

Kotera (1996) estimated the possibility of triple cropping of rice under the climatic conditions of Nam Dinh. His data set was the same as this study. Figure 4-3 shows the estimated potential yield and the total growing days of the triple cropping of rice under the climatic conditions of Nam Dinh. The horizontal axis shows the sowing day of the first cultivation of the triple cropping of rice.

The total growing days for the triple cropping of rice was not less than 365 days. The shortest was 402 days. This shows that a variety with characteristics similar to IR 36 can not be cultivated three times in a year under the climatic conditions of Nam Dinh because it needs too long a growing period.

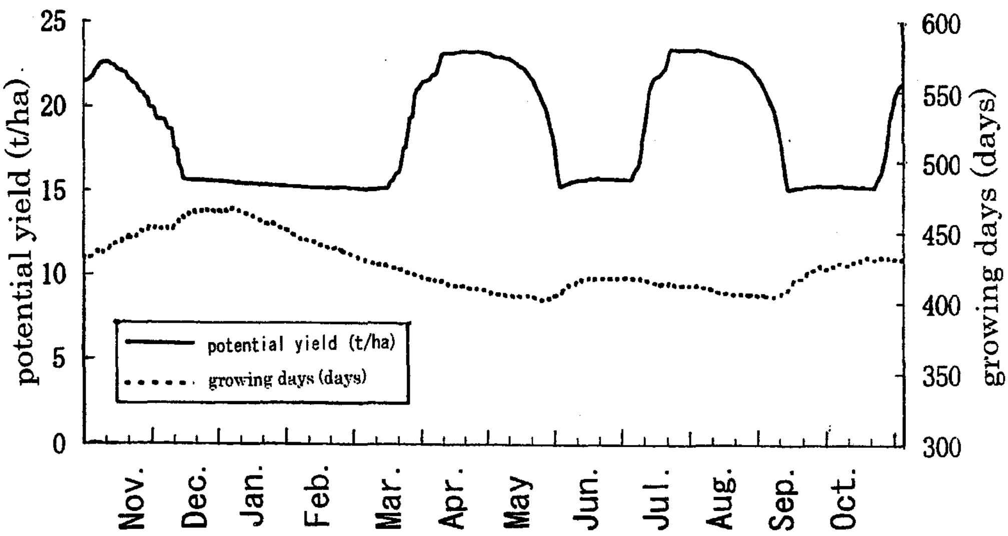


Fig. 4-3. Estimated potential yield and growing days of rice production in CT

Note: The horizontal axis shows the sowing day of the first cultivation of the triple cropping of rice.
Source: Kotera (1996)

The total potential yield of the triple cropping of rice was estimated to be more than 20 ton/ha/year. There were three planting times a year to achieve this yield, which were in the beginning of November, from the end of April to the beginning of May, and from the beginning of July to August.

Can farmers actually sow rice seeds in these periods? At present, farmers in CT use improved varieties whose growing period is 110-130 days. Even though they plant these varieties in those times, at least one crop may be damaged by cold weather in winter. If it is damaged by cold weather, the growing period becomes longer than usual, and it is difficult to achieve a high yield. The fact that the total growing days estimated by the simulation model was more than 365 days shows that the growth of one crop among three crops was delayed by low temperatures and short sunshine duration. In order to cultivate triple cropping of improved rice varieties under the climatic conditions of Nam Dinh, early maturing varieties whose growing period is 80-90 days should be introduced to avoid low temperature and short sunshine duration in winter.

This estimation shows that triple cropping of rice in the Red River Delta is difficult in terms of climatic conditions, especially because of low temperature and the short sunshine duration in winter. It is quite different from the Mekong Delta, where triple cropping of rice is possible.

Next is an analysis of the determinant factors of the double cropping of rice in terms of climatic conditions. Kotera (1996) also estimated the potential yield and the total growing days of the double cropping of rice. The total growing days was the shortest in a year when rice was planted in the beginning of April (Kotera 1996). The summer rice is, however, sown in the beginning of June in CT because it is transplanted in the beginning of July. There are two reasons why the summer rice has to be transplanted in this period. The first is to prevent the spring rice from being damaged by cold weather in winter, and the other is to prevent the summer rice from being damaged by flooding in summer.

If the summer rice is planted in the beginning of April, it has to be transplanted in the beginning of May. May transplanting forces farmers to harvest the spring rice by the end of April and to transplant it by the end of January. According to farmers, spring rice has to be transplanted around *tet* (Vietnamese new-year holiday by lunar calendar), around the middle of February, because transplanting before *tet* is risky for rice seedlings due to cold weather. Spring rice should be transplanted after the middle of February.

The other reason why the summer rice should be planted in the beginning of June (transplanting in the beginning of July) is to prevent the summer rice from being damaged by flooding in summer. The frequency of flood damage in summer is described in the next section.

Besides the factors mentioned above, a hot wind called the "Laos wind" (*gio lao*) is often mentioned to be a factor. It is a hot wind from the northwest (from the Laos direction) in May due to a foehn phenomenon. According to the executive staff of CT, the maximum temperature of the Laos wind reaches 37-38 ℃, and it continues for 5 - 7 days each time. It occurs several times a year. If the time of rice heading and Laos wind overlap, rice yield is greatly reduced due to sterile affects by high temperatures. This is also a reason why the spring rice should be transplanted around *tet*, according to farmers.

Studying the climatic data of 10 years at Nam Dinh, however, it was not found that there was a period of high temperature from April to June. In addition, the author could not get information concerning yield decrease caused by the Laos wind during these 10 years. The executive staff of the cooperative also confirmed there was no effect of the Laos wind during these ten years. Although the Laos wind may be a potential determinant-factor in the rice cropping system, it actually is not one of the main factors.

In summary, this section showed an analysis of rainfall distribution, temperature, and sunshine duration as determinant factors of the rice cropping pattern. As a result, the cropping pattern of rice was explained by temperature and sunshine duration, and the planting time was determined by the operation of the large scale pumping station, cold temperatures in winter, and flooding in summer.

4.3.2. Effects of physical conditions on changes in rice yield

This section shows the effects of climatic conditions on annual changes in the rice yield. Figure 4-4 shows annual changes in the rice yield from 1982 to 1997 in CT. Serious yield-decrease occurred in the summers of 1985 and 1994, and the springs of 1986, 1987, 1988 and 1991. The following section discusses the reason for the yield-decrease.

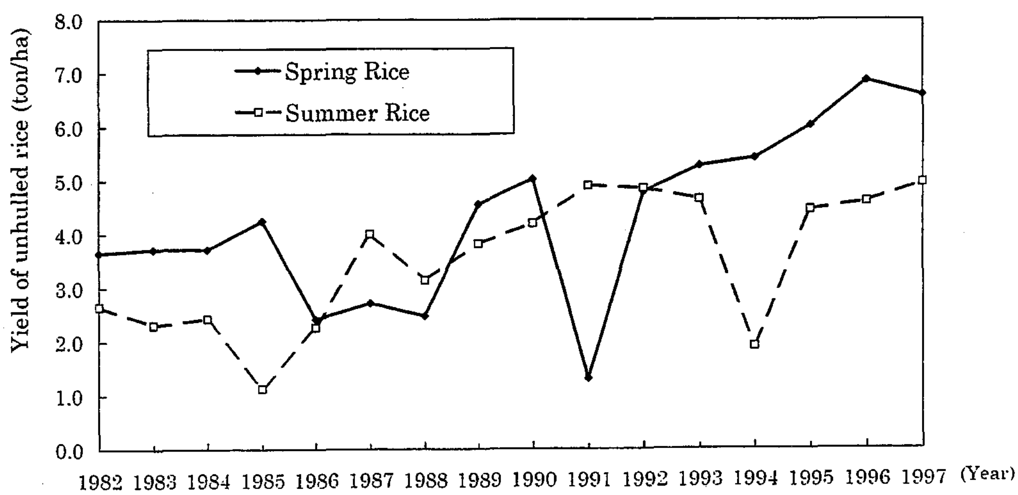


Fig. 4-4. Changes in the actual rice yield of CT since 1982

Source: CT

4.3.2.1. Yield decrease in the summer seasons of 1985 and 1994

According to interviews with farmers, the yield decrease in the spring seasons of 1985 and 1994 were caused by flood damage. Irrigation and drainage operations in CT are linked to the Coc Thanh Pumping Station. Whether flood damage occurs in CT is linked to whether heavy rainfall is beyond the drainage capacity of the Coc Thanh Pumping Station.

There are two ways to drain water at the Coc Thanh Pumping Station. One is drainage by electric pumps, which were made in the Soviet Union and have a total capacity of 32,000 m^3/h, and the other is drainage by sluice gates. During the period from the end of May to October, the Coc Thanh Pumping Station does not open the sluice gates for drainage, because the water level of the Nam Dinh River is higher than that of the main drainage canal. In 1994, they, actually, did not open the sluice gates for drainage from June 17 to November 14. Excess water during the summer is, therefore, drained by pumps.

Whether heavy rainfall is beyond the drainage capacity of the Coc Thanh Pumping Station is estimated by changes in the water level at the main drainage canal of the Coc Thanh Pumping Station, because, although there is a time lag, the water level at the end of main drainage canal shows a balance between the rainfall in the area and the drainage capacity of pumping station.

The Coc Thanh Pumping Station is adjacent to CT. In addition to that, one of the main drainage canals runs through CT from south to north. Fields in the lowest elevation of CT, which is 0.8 meter above sea level, are along the canal. The canal water and that of the fields along the canal infiltrate each other because the embankment of the canal is made of earth. Although there is about a one day time lag, the water level of the main drainage canal is equal to the water level of the field along the canal. Changes in the water level of the main drainage canal, therefore, can be used to approximately estimate the water conditions of the paddy fields in CT.

Figure 4-5 shows the average water level of the main drainage canal and the Nam Dinh River at the Coc Thanh Pumping Station. Data are the 5-days moving average of the mean daily water level for the 11 years from 1985 to 1995. The figures show the average changes in the water level of both the main drainage canal inside the Nam Dinh Polder and that of the Nam Dinh River. The Nam Dinh River rises from May and the water level finally reaches up to 3 meters above sea level on the average, and falls at the end of October. The water level of the Nam Dinh River kept at 1 meter above sea level until the next May.

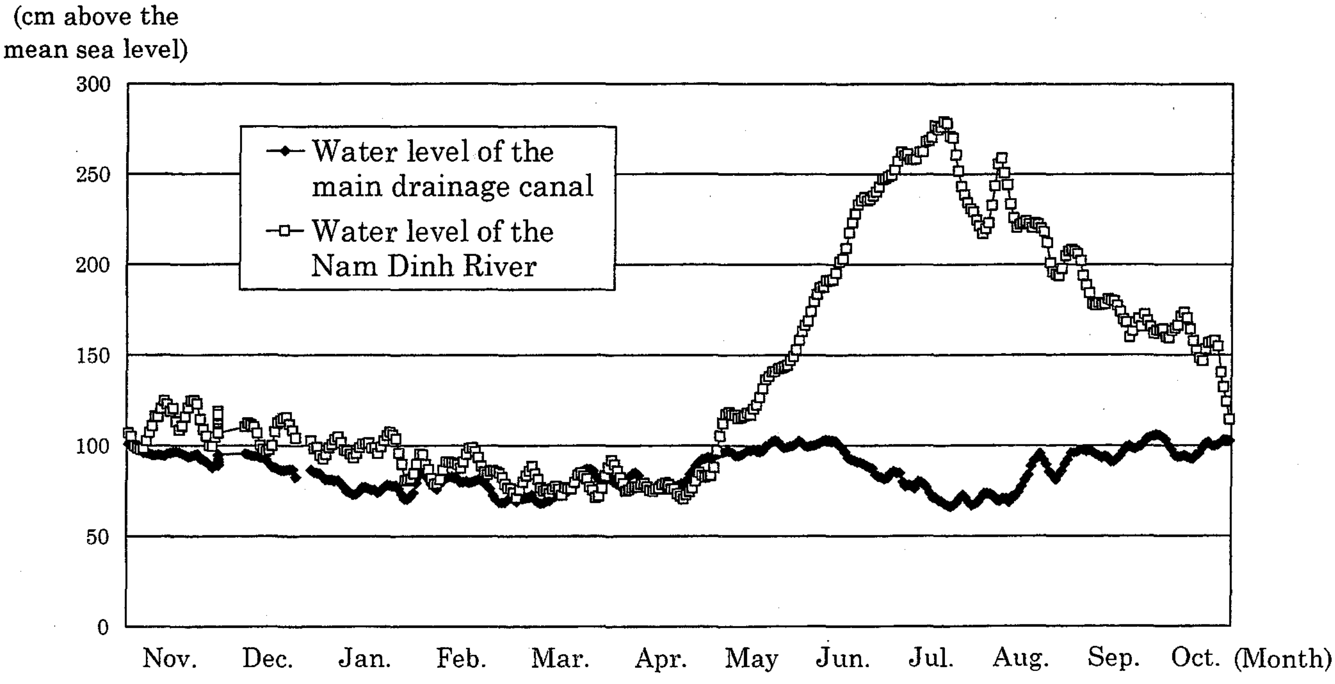


Fig. 4-5. Average water level of the main drainage canal and the Nam Dinh River at the Coc Thanh Pumping Station from 1985 to 1995

Source: Nam Ha Irrigation Company

On the other hand, the water level of the main drainage canal is maintained at about 1 meter above sea level throughout the year. In principle, the Coc Thanh Pumping Station keeps the water level at 0.8 meter in summer and 1.2 meter in spring as a standard water level. If the water level rises above the standard level, water is drained and if it falls, it is irrigated (Kono and Yanagisawa 1996).

As a result, there is almost no period in which the fields of the lowest elevation in CT are able to drain water, because the elevation of the field is 0.8 meter above sea level, which is equal to the water level of the main drainage canal throughout the year.

Flood damage depends mainly on the water level, flooding period, and rice growth. Figure 4-6 shows the number of days when the water level of the main drainage canal was more than 120 cm during the 11 years from 1985 to 1995. The value of the vertical axis is the total days by pentad. If the water level at the main drainage canal is more than 120 cm, more than 70 % of the cultivated area, in which double cropping of rice is cultivated, is covered by flooding (see Table 3-1). Figure 4-6 shows that there are two times of flooding a year. The first period is the 2 months from the middle of May to the beginning of July, and the other is the 2 months and half from the end of August to the beginning of November. Hereafter, these 2 periods are called the June flood and September flood, respectively.

According to Fig. 4-2, the mean rainfall in August is more than that in June or July, but, according to Fig. 4-6, flooding does not occur in August. The period from the end of May until the beginning of July is the time for land preparation, making nursery beds, and transplanting of summer rice. The large scale pumping station, therefore, irrigates water and keeps the water level higher in this period than that of August. June flood may be caused not only by physical conditions, but also by artificial reasons.

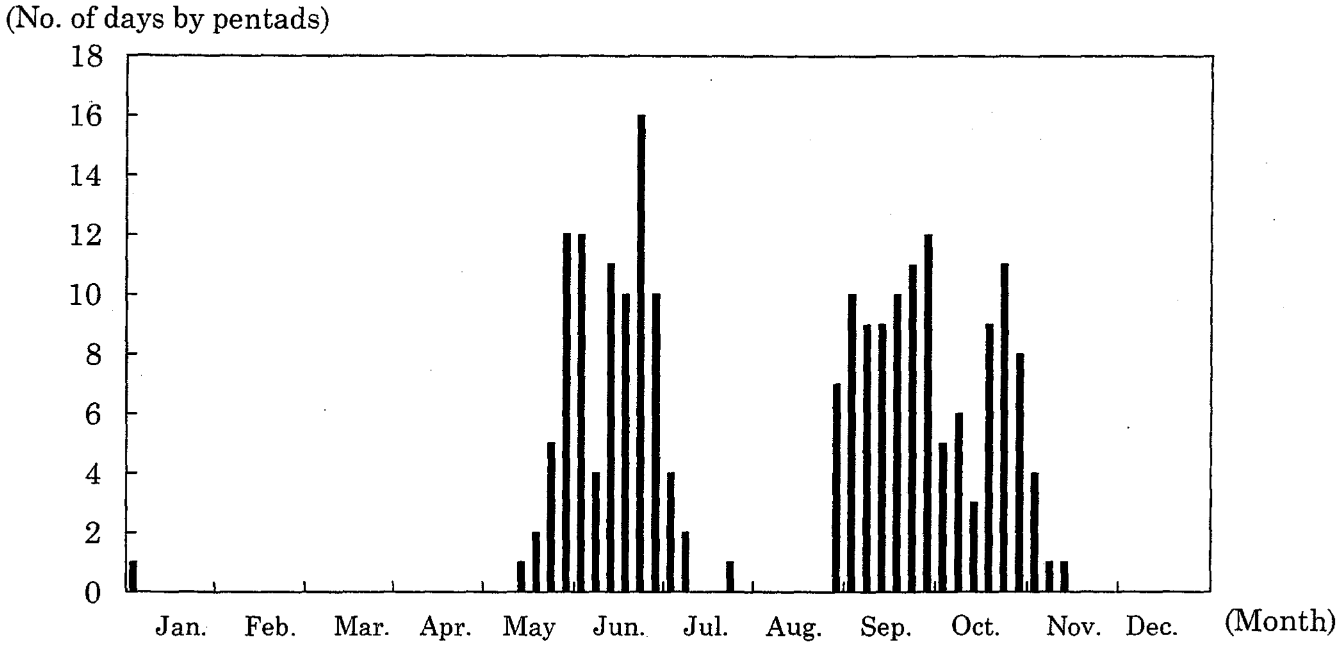


Fig. 4-6. The number of days by pentads when the water level of the main drainage canal was more than 120 cm during the 11 years from 1985 to 1995

Source: Nam Ha Irrigation Company

The June flood occurs around the transplanting time of the summer rice. Flooding after transplanting causes severe damage to rice plants, and farmers have to re-transplant. June flood occurred 7 times in 11 years, the ratio of 64 %.

The September flood occurs in the period from heading of rice to the harvest. As long as the water level of the fields is not more than 1 meter, flood damage seldom occurs because the height of rice plants in this period is more than 1 meter. Even in fields in the lowest part of CT, rice can tolerate flooding at 1.8 meters above sea level.

Although the height of rice plant in this period is more than 1 meter, it does not mean that rice plants are free from flood damage, because rice just after heading is sensitive to flood damage. Furthermore, if rice plants are seriously damaged by the June flood, farmers can re-transplant, but if it is damaged by the September flood, they can not. The September flood damage directly causes a decrease in the final yield. The September flood occurred 8 times during 11 years, ratio of occurrence of 73 %. The reason why farmers have to plant summer rice in the beginning of June will be discussed in the following section. In brief, one reason is to prevent cold damage in spring, and the other is to prevent flood damage in summer.

The planting time of the summer rice has to be determined to avoid the two flooding seasons. The end of June flood is usually the beginning of July. After that, flooding is rare. The summer rice, therefore, should be transplanted after the middle of July. In addition, it is desirable to transplant the summer rice just after the June flood and to grow the rice plants as high as possible by the time the September flood occurs.

Although the above is the general tendency of flooding in summer, it does not discuss the flood damages of 1985 and 1994 which differed from that in other years. The flood whose water level is more than 120 cm occurred in 7 years of the 11 years. Moreover, all of these floods did not cause severe damage to the rice yield because farmers could recover from the damage of flooding through cultivation techniques such as the application of fertilizers.

Figure 4-7 shows the number of days when the water level of the main drainage canal was more than 150 cm during the 11 years from 1985 to 1995. Although, as seen in Fig. 4-6, there are two flood seasons, June and September, the years when the water level reached more than 150 cm were 1985, 1986, and 1994.

The period when water level reached more than 150 cm in 1985 was 20 days, that is, September 1, from September 12 until 29, and October 2 (Fig. 4-8). At the end of August in 1985, the Coc Thanh Pumping Station started drainage by pumping, because they recognized that a tropical cyclone was approaching. As a result, the water level of the main drainage canal fell to 40 cm above sea level in 18 -19 August. It rained heavily from August 23 and continued up to September 1. The total rainfall for ten days was 267 mm. This heavy rainfall made the water level of the main drainage canal higher, which reached 170 cm.

On August 30, the bank near the Vinh Tri Pumping Station collapsed due to the high water level of the Day River, which was flowing along the west embankment of the Nam Dinh Polder. The result was that southern part of Nam Dinh Polder was severely flooded.

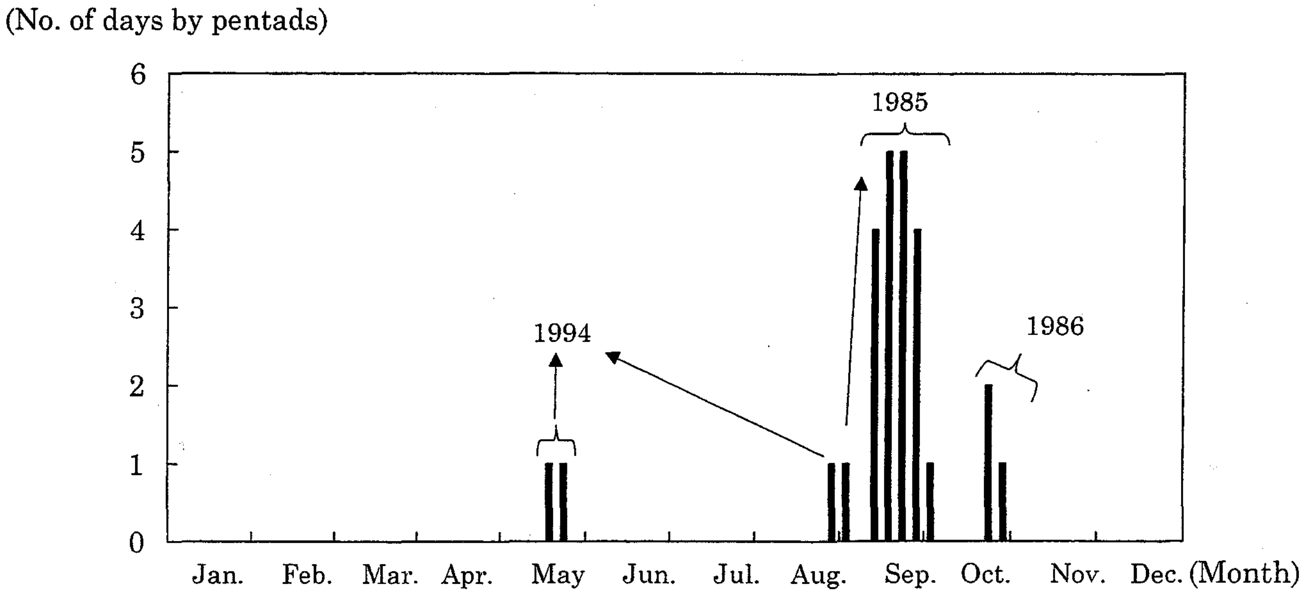


Fig. 4-7. The number of days by pentads when the water level of the main drainage canal was more than 150 cm during the 11 years from 1985 to 1995

Source: Nam Ha Irrigation Company

After that, there was almost no rainfall for 7 days from September 2 to 8, though it heavily rained again from September 9 to 12, during which total rainfall for 4 days was 417 mm. On September 11, the amount of rainfall was 198 mm/day. This rapidly made the water level of the main drainage canal high because water from the former rainfall was not completely drained. The water level of the main drainage canal did not fall from 190-198 cm for 7 days from September 13 to 19, and then gradually went down.

When the water level of the main drainage canal was 190 cm, that of paddy fields in the lowest part of CT was 110 cm from the ground level. In many of paddy fields cultivating double cropping of rice, the water level of the fields was 60 - 100 cm.

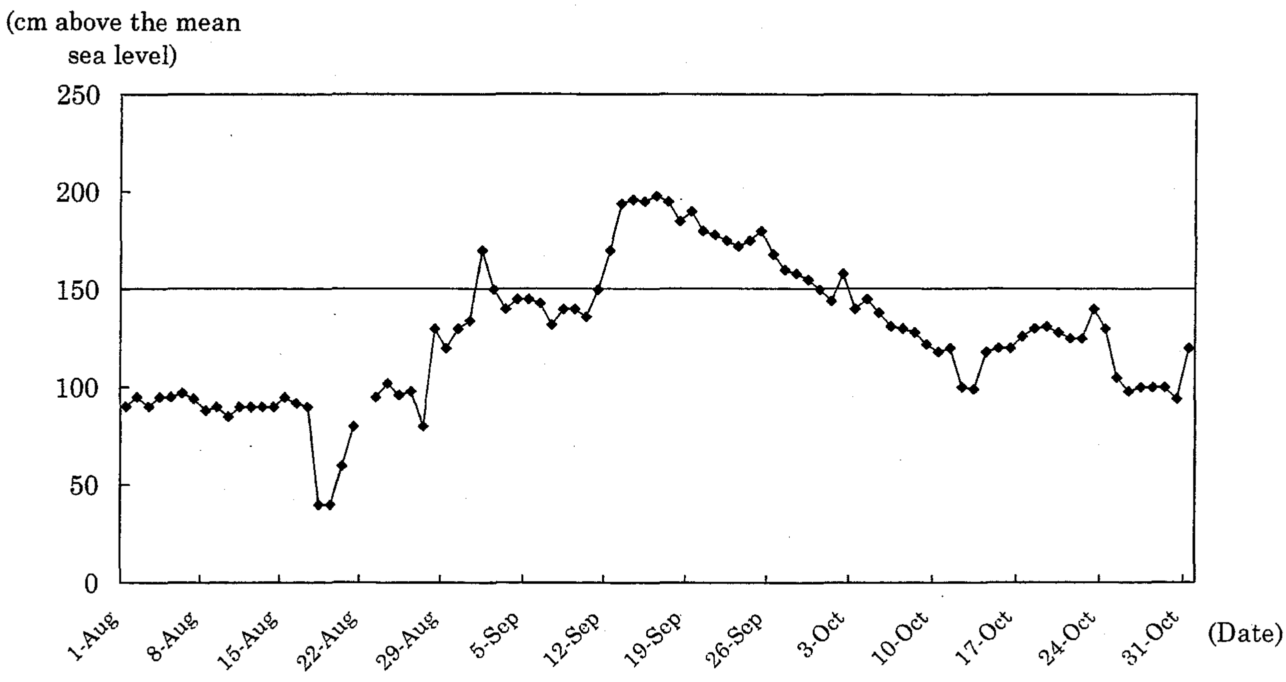


Fig. 4-8. Changes in water level of the main drainage canal at the Coc Thanh Pumping Station in 1985

Source: Nam Ha Irrigation Company

At that time, the rice was already headed and the height of the rice plants should have been about 100 cm from the ground level. Only the tip of rice was observed over the water surface. The rice was under water for more than one week. This long term flooding just after heading was the main reason for the serious decrease of rice yield in 1985.

Flooding in 1986 occurred at the end of October. The period when the water level of the main drainage canal was more than 150 cm was 4 days from October 24 to 27. One month has already passed from the rice heading, and it was already in a full ripe stage. As a result, flooding did not affect the final rice yield because farmers had already harvested the rice before flooding.

Flooding in 1994 occurred at the end of May and August. Flooding at the end of May did not affect the rice yield because farmers harried to harvest the spring rice before the flooding. Flooding at the end of August affected the rice yield seriously. The water level of the main drainage canal was not less than 130 cm for 4 days from August 31 to September 3. It fell to 120 cm on September 5. This period was about the 40th day after transplanting. The height of the rice was about 50 cm. Rice in the lowest part of CT was completely flooded for more than 4 days. In the other fields with double cropping of rice, the tip of the rice was observed on the water surface. As a result, a lot of the rice plants died and the remaining was also lower in quality. However, farmers did not have enough rice and had to purchase it because it was too late for farmers to re-plant rice.

4.3.2.2. Yield decrease in the spring seasons of 1986, 1987, 1988 and 1991

Both the executive staff of the Nam Ha Irrigation Company and farmers in CT regarded that a mistake in pump operation was the reason for the yield-decrease of the spring of 1991 (Yanagisawa and Kono 1997). Changes in the water level of the main drainage canal in 1991 did not clearly show a rise of water level. This does not contradict with the farmers remembering that the flooding was caused by little rainfall, which did not affect the rice as usual. Although the details are not known, it is considered that flooding at the heading period of rice caused serious yield decrease.

Compared with the yield decrease by flooding in the summer seasons of 1985 and 1994, and by miss-operation of the large pumping station in the spring of 1991, those of the spring seasons of 1986, 1987, and 1988 were not clearly remembered by the farmers in CT. It is difficult to identify the reasons for the yield decrease from the annual changes in rainfall, temperature, and sunshine duration. As will be discussed later, various kinds of rice varieties in spring have been diffused since 1992. The annual change in rice yield in spring before 1992 might be bigger than that after 1992, or, it was a time when agricultural market in Vietnam was under reconstruction due to the *doi moi* policy and political changes in East Europe. Although the reasons might have originated from political unrest, this is no more than a guess.

The effects of physical conditions, especially climatic factors, on rice production were considered in this section. Simulation model of rice yield showed that double cropping of rice was inevitable in the Red River Delta and the cropping pattern was determined by cold temperature in winter and two floodings, i.e. the June flood and September flood, in summer. Annual changes in rice yield showed that serious yield-decrease was mainly caused by flooding.

4.4. Rice production and cultivation techniques: Effects of cultivation techniques on rice cropping patterns and annual changes in rice yield

4.4.1. Effects of cultivation techniques on rice production at the village level

Except for the years of serious rice yield-decreases, there is a tendency that the rice yield both in spring and summer has been increasing since the 1980s. Especially the spring rice yield in 1996 reached 6.9 ton/ha, which was the highest in 16 years. It is considered that this tendency is not due to climatic changes, but due to artificial improvements such as the introduction of new varieties. In this section, cultivation techniques as determinant factors of the rice cropping system and changes in yield in the recent years are considered.

4.4.1.1. Rice varieties in the Red River Delta

Before the 1950s, traditional varieties were mainly used in the Red River Delta. New varieties from foreign countries have been introduced since 1955 (Dap 1980). In the late 1960s, many improved varieties of IRRI were introduced and bred again in Vietnam to be able to grow under the climatic conditions of Vietnam (Thuat 1996: personal communication). CR203 was also a variety bred from a line (IR8423-132-622) introduced from IRRI in 1978, and released in 1985. It rapidly became common after the release. The cultivated area in the late 1980s was estimated about 90 % of the total paddy area in the Red River Delta (Thuat 1996).

The purpose of this section is not to describe the general changes in rice varieties in the Red River Delta. In order to understand changes in rice varieties in CT, agronomic details concerning the introduction of CR203 and the background of the changes in the cropping system and yield are described.

According to Mr. Nguyen Cong Thuat, who was a member of Vietnam Agricultural Science Institute (*Vien Khoa Hoc Ky Thuat Nong Nghiep Viet Nam*) in those days, and a famous rice-breeder, who bred C70, TK (glutinous rice variety), and other varieties, except for CR203, the reason for the rapid diffusion of CR203 in the Red River Delta can be summarized as follows: (1) tolerance to the brown planthopper, (2) a high yield, (3) a short growing period, and (4) high quality. Regarding "(2) high yield", it is well known in Asian countries as a green revolution. "(4) high quality" means that the taste of CR203 was better than the older varieties bred by IRRI. Factors (1) and (3) are described as follows.

Tolerance to the brown planthopper

Although damage by the brown planthopper had not been observed in fields of extensive farming in the Tropics until the 1970s, it has occurred since then, as the area of semi-dwarf type of rice varieties increased (AICAF 1997). The Red River Delta was not an exception.

In the late 1960s, the brown planthopper (*ray nau* in Vietnamese, *Nilaparvata lugens*) started appearing in the Red River Delta, after new varieties were introduced from IRRI and a large amount of nitrogen fertilizer was applied. The area damaged by the brown planthopper is estimated to have been approximately 100,000 ha in the Red River Delta in the early 1980s, which was the most serious period. After the introduction of CR203 with tolerance to the brown planthopper, the damage rapidly decreased.

In addition to that, greater application of nitrogen fertilizer gave rise to a new problem in the rice production in the Red River Delta. Soil phosphorus deficiency became a limiting factor in rice production. Although great application of nitrogen fertilizer to IRRI varieties created a yield increase in the first and second years, it then stopped increasing in the third and fourth years, and, in some cases, it conversely even decreased. Great application of nitrogen fertilizer promoted the vegetative growth of rice, and, as a result, the phosphorus in the soil was absorbed, causing phosphorus deficiency. After recommendation of applying 45-60 kg/ha of P_2O_5, the rice yield recovered.

Short growing period

Introduction of CR203 improved land use ratio, because it enabled farmers to plant upland crops in the paddy field. The main rice varieties before the new IRRI varieties were introduced were long maturing ones in the spring season with a 200 day growing period, and middle-long maturing ones in the summer season with a 130 day period. The growing period of CR203 was, however, 150-160 days in spring and 115-120 days in summer (Dich 1995). Shortening of the rice growing period made upland crop planting possible. Maize and soybean were planted in the autumn-winter season and potato, sweet potato, and peanuts in the winter-spring season.

CR203, however, rapidly diffused and replaced other improved varieties. In the 1990s, the area planted with CR203 was 50% in spring and 60-70 % in summer. It had reduced to 10-15 % in spring and 20-25 % in summer in 1996. The same tendency was also observed in CT.

4.4.1.2. Changes in rice varieties in CT and the cropping system

Figure 4-4 shows that rice yield has tended to increase since the 1990s except for decreases in 1991 and 1994. This is partly attributable to the introduction of new rice varieties.

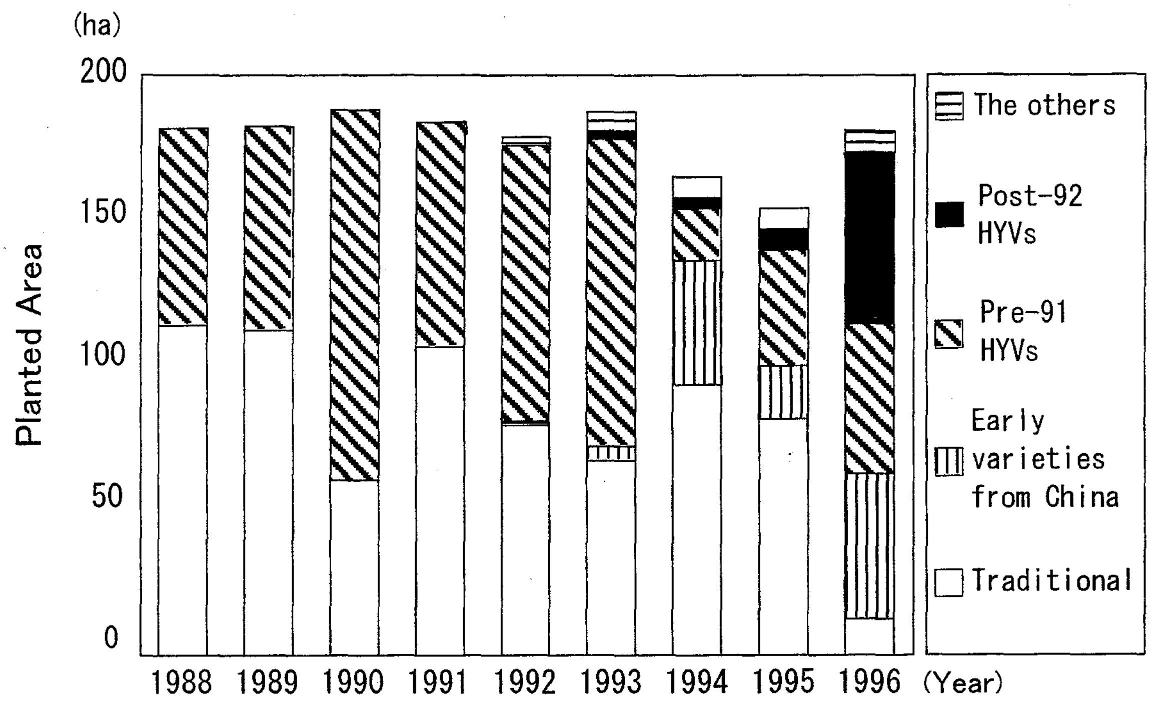
Rice varieties both in the spring and summer in CT have diversified since 1992 (Fig. 4-9). Before 1991, only 2-3 varieties were cultivated. Since 1992, the number of varieties has increased to 6-9 in spring and to 7-8 in summer. In this section, the author classifies these varieties into 6 groups with the following characteristics:

1) Traditional Varieties; old varieties adopted before 1980
2) Acid-Tolerant Varieties; Tolerant varieties against low soil pH
3) Post-92 HYVs; High yielding varieties adopted after 1992
4) Pre-91 HYVs; High yielding varieties adopted before 1991
5) Early Varieties from China; Early maturing varieties introduced from China
6) others; others such as glutinous rice

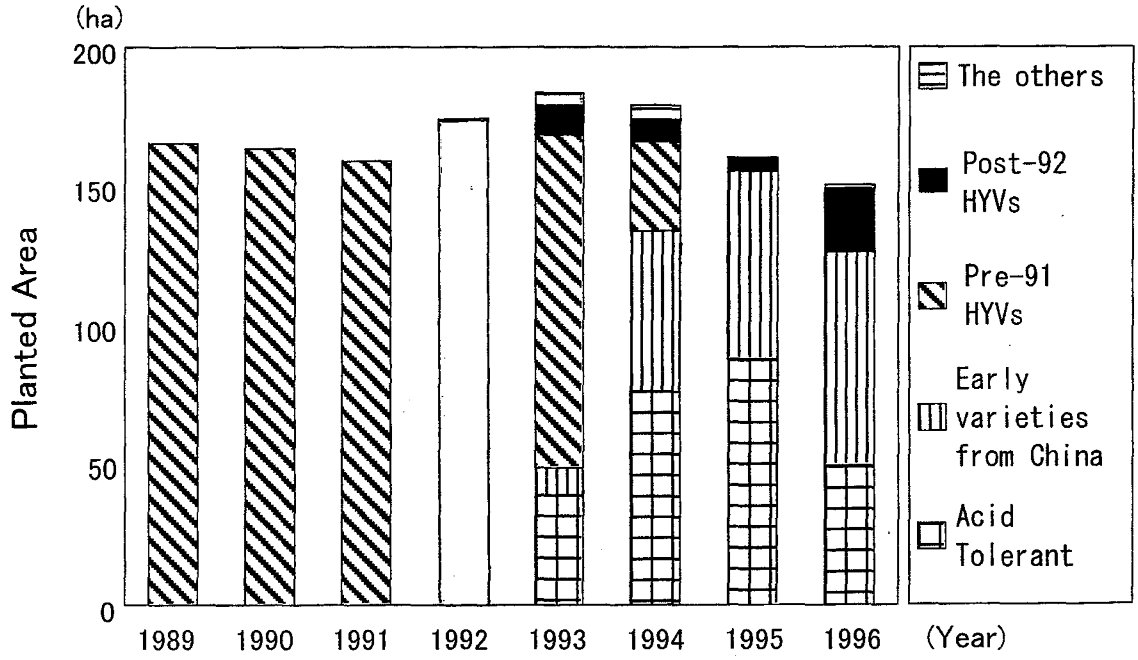
Rice varieties in the spring season

Figure 4-9 shows the rice area planted with different varieties in CT. In 1980s, there were only 2-3 varieties, including CR203. Many varieties have been introduced since 1992 and all of the old varieties adopted before 1991 have been replaced with new ones in the spring season.

The planted area of acid tolerant varieties in 1996 were 33 %, post 1992 high yielding varieties (HYVs) 15 %, and early maturing varieties from China 51 %. Each variety was planted in the lowest part of the low elevation fields, the low, and the middle elevation fields, respectively. Acid tolerant varieties in the low fields with acidic soil, and HYVs contributed to the increase in the rice yield. Therefore, yield in the low fields in 1996, for example, was 6.2 ton/ha, the highest between 1989 and 1991. HYVs adopted after 1992 in the low elevation fields also contributed to an increase in the yield.



Summer season



Spring season

Fig. 4-9. Rice planted area with varieties from 1989 to 1996 in CT

Note: In spring of 1992, 5 varieties including 3 new ones, were planted. The area planted with variety is not known.

Source: CT

The early maturing varieties from China planted in the middle elevation fields in the spring season have a 5-10 days shorter cropping period compared with the HYVs adopted before 1991, including CR203. In addition, as mentioned later, *ma nen* (see Chapter 5, a young seedling planting method) permits a delay in the transplanting time. The period from transplanting to harvesting of the early maturing varieties from China can also be shortened by 35-40 days in comparison with the former varieties. Vegetable planting in this period increased the farmers' cash income. That is why the vegetable area was expanded as early maturing varieties from China expanded.

Rice varieties in the summer season

Rice varieties in the summer season have also diversified since 1992. The transition to the new varieties, however, was not so rapid as with spring rice. One of the reasons is that one "traditional" variety, called *moc tuyen*, with a stem length of 150-160 cm, is photoperiod sensitive.[1] Although the yield is low in comparison to the new varieties, it is widely planted in low elevation fields, because it was tolerant to waterlogging. *Moc tuyen* was one of the main summer season varieties in the CT before 1995.

The planted area in 1995, however, decreased 15 % from the previous year. The reasons for this were: (1) increase in maize cultivation in the winter season, and (2) diffusion of new seedling growing methods, called *kho am*.

(1) maize cultivation in the winter season

Since 1996, maize has been planted in low fields, where rice was

[1] *Moc tuyen* was introduced to Vietnam from China in the 1960s. In this chapter, I call this "traditional " variety.

formerly planted twice a year in CT. In these fields, the summer rice was a traditional variety with a long cropping period, 105-110 days long, and harvested in the middle of October. If maize is planted after the harvesting of summer rice, however, the maize harvesting time will overlap the land preparation and the transplanting time of spring rice. This is why early maturing varieties were planted in these fields in summer. The early maturing varieties are not as tolerant of waterlogging as the traditional ones, but the CT staff members expected that any yield decrease would be compensated for by maize production.

Extension activity of maize cultivation by the cooperative was, after all, unsuccessful, because most of farmers could not get a harvest. It is considered that the moisture content in the paddy soil was too high to grow maize.

In addition, farmers complained that maize cultivation required additional labor just after the harvest of the summer rice, because they could not plant the seed directly, but had to transplant the maize to shorten the growing period. Maize seeds were planted on a small block (5×5×5 cm) of mud, and seedlings were transplanted with the block of mud. This transplanting required hard work for farmers just after the harvest of the summer rice.

(2) Diffusion of new seedling method, *kho am*

After the failure of maize introduction, the area of *moc tuyen* did not increase, because a new variety with a good initial growth, which is called *tap giao*, was introduced, and at the same time, a new seedling method called *kho am* in Vietnamese was diffused.

One of the most serious problems during the seedling period of the spring rice was damage caused by low-temperatures, and that of the summer season was waterlogging caused by heavy rainfall. Usual nursery beds were located in low fields, and farmers used pump drainage as the main measure to avoid waterlogging.

In order to solve this problem, the *kho am* method was developed. It then became possible to avoid waterlogging damage during the seedling period by sowing seeds in the low to middle elevation fields, and to avoid waterlogging damage after transplanting by transplanting tall seedlings with a height of about 30 cm. Furthermore, introduction of the *tap giao* variety, a F1 variety that grows rapidly, has allowed farmers to more easily grow large seedlings. The planted area was 5 % of the rice cultivated area in 1995, but it increased to 33 % in 1996. The planted area of *tap giao* expanded in low fields, where *moc tuyen*, a long-stem and traditional variety, was previously planted to avoid waterlogging damage.

In comparison with spring rice, the grain yield of summer rice did not increase sharply after 1988. The continued preference for the traditional variety makes it clear that the main limitation to introducing the new variety is waterlogging damage. The farmers, so far, believe that the only way to avoid waterlogging damage in summer is by means of pump drainage, which can not be done at the farm-level, but depends on the province or the Nam Ha Irrigation Company level. The development of new seedling methods, however, originated from the farmers, and the diffusion of new varieties may allow greater stability and increases in the rice yield in summer.

Rice yield has been increasing since 1990. This is mainly because rice varieties have been improved and diversified. After the transition to a market oriented economy, many varieties were introduced from foreign countries and, bred in Vietnam at that time. As a result, farmers could use more suitable varieties for their fields, including acid and cold tolerant varieties and high yielding ones. As the rice varieties changed, in addition, cultivation techniques at the farmer-level such as seedling raising methods were also improved to avoid flooding damage of summer rice and to expand vegetable fields. Both state level efforts to improve and diversify rice varieties and farmer level improvement of cultivation techniques have increased the rice yield.

4.4.2. Effects of cultivation techniques on rice production at the farmer level

In order to evaluate agricultural intensification, this section describes the effects of cultivation techniques on rice production at the farmer level based on the daily agricultural practices of farmers.

The author conducted a research to record the agricultural practice of farmers in CT to understand their cultivation techniques of rice production. Eighteen fields, which were geographically scattered in CT, were selected for this survey. The period of research was from January until the end of November, 1998. Research items asked farmers to record their daily agricultural practice were working hours, a list of inputs, and the growing stages of the rice.

Figure 4-10 shows the location of the 18 fields. The cropping patterns of all the fields were the double cropping of rice. There were no upland crops throughout the year.

Table 4-1 shows the area, yield, and rice varieties of the 18 fields. The average cultivated area was 456 m^2, and the average rice yield was 5.9 ton/ha. The yield in spring was 6.1 ton/ha, which was higher than that of 5.8 ton/ha in summer.

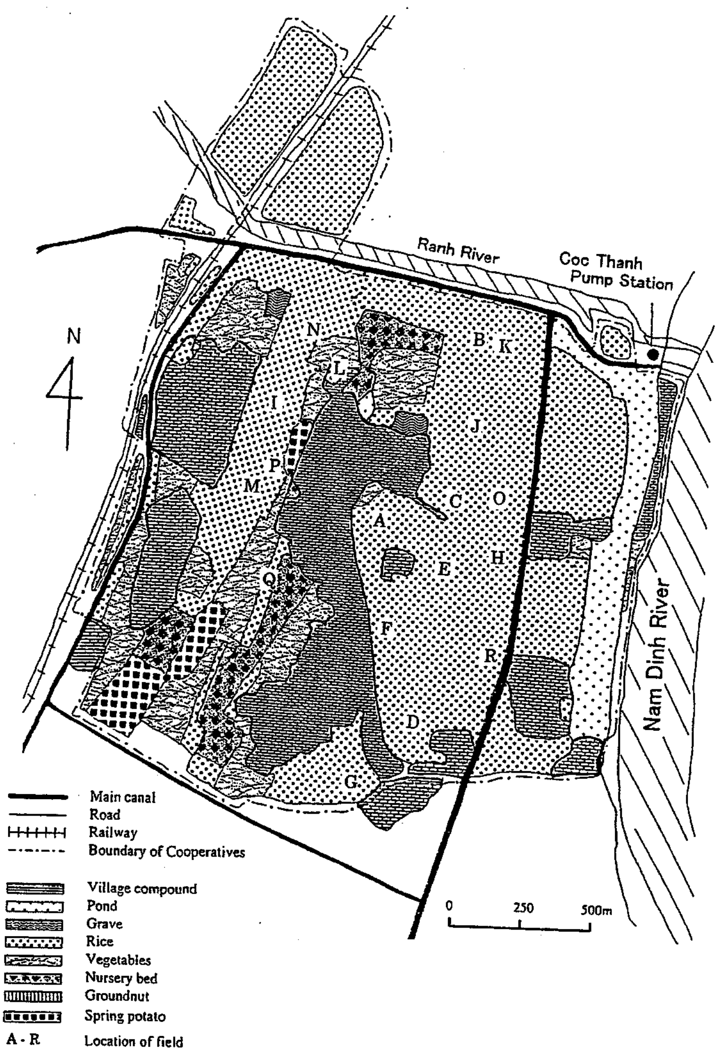


Fig. 4-10. Location of the 18 fields and landuse in the early spring season of CT

Rice variety was mainly *ai 32* in spring and *tap giao* in summer. Both varieties were originally bred in China. The growing period of *ai 32* was 120-125 days in spring and that of *tap giao* was 120-125 days in summer. Besides these varieties, *c70* and *du* were planted. The former was a spring variety which has a tolerance to acidity and cold weather, and the latter was a traditional variety for the summer season. *Du* was close to *Tam* variety and was planted in about 2 % of the total rice area of North Vietnam in the early 1960s (Dap, B.H. 1964).

Table 4-1. Area, yield, and rice variety of the 18 fields

Field	Area (m^2)	Yield (ton/ha)			Rice variety	
		Spring	Summer	Average	Spring	Summer
A	1,032	7.9	9.2	8.6	*ai 32*	*tap giao*
B	360	7.1	6.6	6.8	*ai 32*	*tap giao*
C	624	7.1	6.2	6.7	*tap giao*	*tap giao*
D	384	7.1	5.5	6.3	*ai 32*	*tap giao*
E	264	6.3	5.5	5.9	*tap giao*	*tap giao*
F	360	5.6	5.8	5.7	*ai 32*	*tap giao*
G	456	5.4	5.9	5.7	*ai 32*	*tap giao*
H	648	5.6	5.7	5.7	*ai 32*	*tap giao*
I	600	5.7	5.4	5.5	*ai 32* & *tap giao*	*tap giao*
J	936	6.2	4.7	5.5	*ai 32* & *tap giao*	*tap giao*
K	624	5.2	5.6	5.4	*ai 32*	*tap giao*
L	108	6.9	3.8	5.3	*ai 32*	*nep som*
M	282	5.4	5.2	5.3	*ai 32*	*tap giao*
N	720	5.1	5.2	5.1	*ai 32*	*tap giao*
O	192	5.6	4.6	5.1	*ai 32*	*tap giao*
P	264	4.8	5.0	4.9	*c70*	*tap giao*
Q	80	6.6	2.0	4.3	*ai 32*	*du*
R	432	3.9	4.0	3.9	*c70* & *ai 32*	*tap giao*
Total	8,366					
Average	465	6.1	5.8	5.9		

4.4.2.1. Plowing and harrowing

In the fields with double cropping of rice (Type 8), farmers immediately plowed after harvesting of the previous season rice to dry the soil for the spring rice and to prepare the land for the summer rice. After two plowings, the land was leveled by a comb harrow. Plowing and harrowing for land preparation were, therefore, usually done 3 times, using diesel tractors and water buffaloes. In CT, human power was not used for the force of traction for plowing and harrowing. Out of the 18 fields, 13 fields were plowed by tractor, 4 fields by water buffalo, and 1 field by hoe. The area plowed by tractor was 6,156 ㎡ (74 %), 2,130 ㎡ (25 %) water buffalo, and 80 ㎡ (1 %) hoe. The total number of tractors in CT was 1 in 1993. There were already 8 tractors in 1996.

Plowing was done by the owner of the tractor and water buffalo. The cost of plowing in 1998 was 12 kg/*sao* of unhulled rice (18,000 dong/*sao*) by tractor, and 10 kg/*sao* (15,000 dong/*sao*) by water buffalo. This cost included the all practices from the first plowing until leveling before transplanting. The cost was paid by cash after the cropping season. Eighty ㎡ by hoe was plowed by household labor.

Table 4-2. Working hours for rice cultivation by agricultural practice

	Workings hour by practice (hours/ha)			Ratio (%)		
	Spring	Summer	Total	Spring	Summer	Total
Plowing and harrowing	82:58	98:18	181:17	4.3	6.2	5.2
Levee building	40:08	46:54	87:03	2.1	3.0	2.5
Irrigation and drainage	36:27	12:09	48:36	1.9	0.8	1.4
Transplanting	508:24	408:11	916:36	26.3	25.9	26.1
Application of fertilizer	163:06	142:28	305:34	8.4	9.0	8.7
Weeding	247:13	158:34	405:48	12.8	10.0	11.6
Thinning	15:44	6:16	22:00	0.8	0.4	0.6
Application of agri. chemicals	67:32	67:20	134:52	3.5	4.3	3.8
Harvesting	394:33	368:44	763:17	20.4	23.4	21.8
Threshing	46:20	47:58	94:18	2.4	3.0	2.7
Winnowing and drying rice	288:07	196:03	484:10	14.9	12.4	13.8
Drying and process of the rice straw	23:42	22:36	46:19	1.2	1.4	1.3
Other	15:56	3:01	18:57	0.8	0.2	0.5
Total	1930:15	1578:39	3508:54	100.0	100.0	100.0

Plowing for spring rice was conducted within one month after the harvest of the summer rice, because a period from harvesting of summer rice to plowing for spring rice was the only chance to be able to dry the soil of the paddy field in the year.

Working hours for plowing and harrowing occupied 5 % of the total working hour of rice cultivation a year (Table 4-2)[2]. Spring rice needed relatively more working hours than summer rice.

4.4.2.2. Water management

After plowing, water is irrigated from the main irrigation canal into CT. Irrigation water for rice cultivation in CT depends on water pumped up by the Coc Thanh Pumping Station. When the Coc Thanh Pumping Station irrigates water, CT takes it from the main irrigation canal into CT by gravity and sends it to all the paddy fields through secondary and tertiary canals.

Twelve members of water management brigade (*doi thuy nong*) were in charge of water management in CT. They divided CT into 11 areas and each member manages one area. The operation of water in each area was decided by the member of water management brigade and the head of the brigade. Information on irrigation and drainage comes down from Nam Ha Irrigation Company to CT through the company's Vu Ban District branch. This information finally reached the water management brigade and households.

Irrigation water taken from the main irrigation canal by sluice gates was then distributed to farmers' fields by gravity. The farmers have to do was to get water from the secondary and tertiary canal and maintain it in their fields. For example, they constructed small scale weirs, built levees to hold the water, and supplemented the irrigation by swing baskets, and so on. Although these practices, especially irrigation by human power such as

[2] Working hours by the owners of tractors and water buffaloes is not included.

swing baskets, are thought to be very hard work, it is relatively not such a hard work for the CT farmers because of the advantage of being located adjacent to the Pumping Station, which applied to the drainage situation, too. The ratio of working hours for water management, including both irrigation and drainage, was 2 % in spring and 1 % in summer.

4.4.2.3. Nursery making, pulling of the rice, and transplanting

Seedlings are raised on nursery beds. There are three types of nursery beds in CT, that is, *ma duoc*, *ma nen*, and *ma kho am*. *Ma nen* is a protected upland nursery for the spring rice. After mud is spread in the home garden or in higher elevation fields near a farmhouse, the rice seeds are sown. In the case of spring rice, when seedlings reach a height of 10-15 cm with 2-3 leaves, they are transplanted to the paddy fields. *Ma nen* prevents rice nurseries at higher elevations from being damaged by low temperature during the seedling period of spring rice with covering by vinyl film. Although *ma kho am* is also an upland nursery, it is for the summer rice to grow into tall seedlings to prevent it being damaged by flooding after transplanting. *Ma duoc* is a usual nursery for both seasons. Both *ma nen* and *ma kho am* are common, and the area of *ma duoc* is decreasing.

After rice seeds are sown on nursery beds, it takes 20 days before transplanting for *ma nen*, 20-30 days for *ma kho am*, and 2 months for *ma duoc* for spring rice and 1 month *ma duoc* for summer rice.

The transplanting period of the summer rice is from the beginning of July and spring rice from the beginning of February. The time lag between the earliest and latest transplanting was about 14 days, which depended on the variety. Various kinds of varieties with different growing periods were transplanted to not over concentrate transplanting at one time.

Transplanting was a big event that required a lot of labor in rice cultivation. The work of transplanting consisted of pulling the rice seedlings, carrying them to the field, and transplanting them. The ratio of the working hours spent for transplanting was 26 %, which was the most among the agricultural practices[3].

The working hours spent on pulling the rice seedlings differed by variety, namely by the method of nursery beds making. Working hours per unit area for the pulling of the rice seedlings was 33 hours 16 minutes/ha for *ai 32*, 434 hours 1 minute/ha for *c70*, and 84 hours 41 minutes/ha for *tap giao*. The methods of nursery beds making for these varieties are *ma nen*, *ma duoc*, and *ma kho am*, respectively. The working hours for *ma nen* were few because it was a nursery beds of young seedlings and easy to handle. On the other hand, the working hours for *ma duoc* were many because the farmers pulled the seedlings in a nursery beds that was muddy, so the seedlings had to be washed before they were carried to the paddy fields. It took more than 10 times as long as that of *ma nen*.

The average working hours for the pulling of seedlings was 83 hours 18 minutes/ha in summer and 78 hours 38 minutes/ha in spring.

The working hours for transplanting per unit area were 458 hours 42 minutes for the spring rice and 334 hours 11 minutes for the summer rice. The reason why the working hours for the spring rice were greater than that of the summer rice was due to planting density.

According to a booklet distributed to farmers by the Nam Dinh Seed Company, the optimum planting density was 38-40 rice stubble/㎡ and 1-2 plants/rice stubble for *tap giao*, 45-50 rice stubble/㎡ and 3-4 plants/rice

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[3] This table does not include the working hours for making of nursery beds because it was calculated on the basis of paddy fields.

stubble for *ai 32*, and 40-45 rice stubble/m² and 3-4 plants/rice stubble for *c70*. Actually, the planting density of *tap giao* was sparser than that of *ai 32*. It is considered that the difference in planting density caused the difference in working hours needed for transplanting.

The series of practices from the pulling of rice to transplanting is a big event in rice cultivation. Farmers provide the needed labor not only from their own household, but also from relatives through labor exchange. The owners of 12 fields in spring and 9 in summer provided labor for transplanting through labor exchange. On the other hand, the owners of 5 fields in spring and 9 in summer provided labor from their household. There was only one field that hired labor for transplanting in spring. The ratio of working hours by labor exchange to the total working hour for transplanting was 32 % in spring and 34 % in summer. One third was provided by labor exchange.

The ratio of working hours for transplanting by labor exchange differed between fields. What is the determining factor of the ratio of labor exchange? Figure 4-11 shows the average ratio of labor exchange to the total working hours for all the agricultural practices. The horizontal axis shows the area per person and the vertical axis shows the ratio of labor exchange to the total working hours. This figure does not show that the larger the area per person is the higher the ratio of labor exchange is. Figure 4-12 shows the average ratio of labor exchange to the total working hours for transplanting. This also shows the same tendency. Labor in a household is not a determining factor of the ratio of labor exchange to the working hours. It is related to relationship between family members. For example, the owner of field Q had 80 m² of paddy field and the household labor was two persons who were more than 60 years old. Even though the

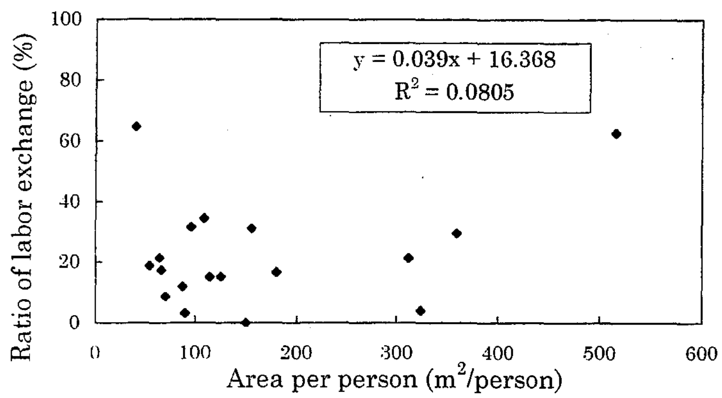


Fig. 4-11. Relationship between ratio of labor exchange to the total working hours and area per person

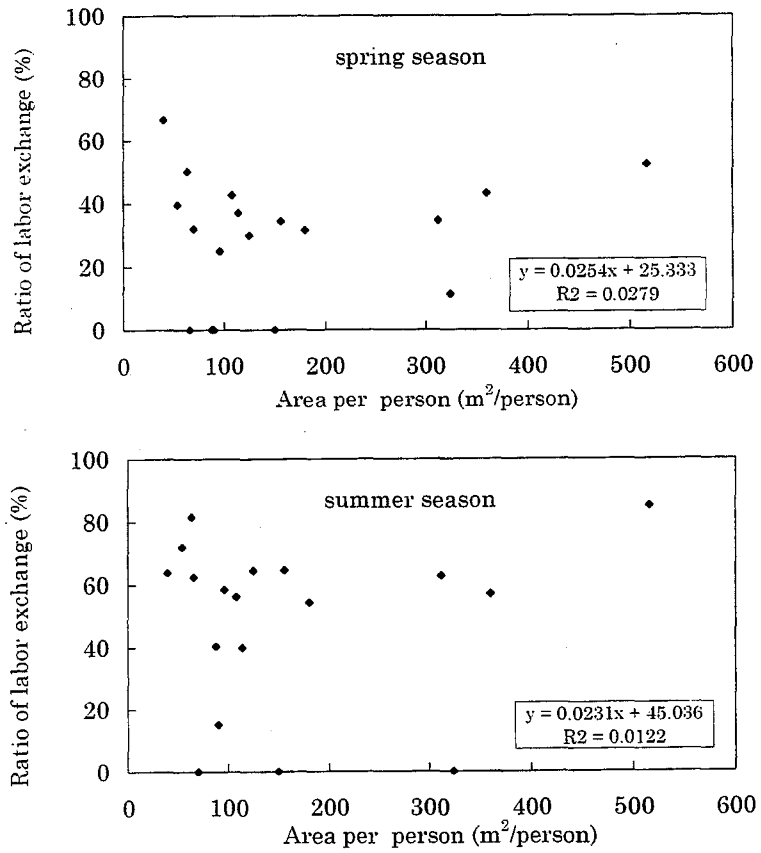


Fig. 4-12. Relationship between ratio of labor exchange to the working hours for transplanting and area per person

area was small, two-thirds of the total working hours depended on labor exchange both in spring and summer. The transplanting labor was done by their children. Although it is true that this could be called labor exchange, it is hard to believe that the old couple could return the same amount of labor as that they received. The family managed all of the fields of the family members in one body.

4.4.2.4. Fertilizer application

Fertilizer application, including chemical fertilizers and manure, was essential for rice cultivation in CT. Nitrogen fertilizer was applied as a basal dressing when transplanting. All the farmers used urea as nitrogen fertilizer. In addition, the top dressing was applied 14, 30, 45, and 60 days after transplanting. The type and amount of chemical fertilizers for the top dressing differed between fields. Usually, nitrogen was applied 2 times, and phosphatic and potash fertilizers once during a crop season.

Chemical fertilizers were applied by hand. Manure, which was provided by farmers to mix with pig dung and rice straw, were also scattered equally when land leveling. Labor exchange was seldom observed. The average working hour for fertilizer application was 305 hours 34 minutes hours/ha, which occupied 8.7 % of the total.

The types of chemical fertilizers used were *dam urea* (urea, content of N is 46 %) as a nitrogen fertilizer, *supe lan* (content of P_2O_5 is 16-24 %) as a phosphatic fertilizer, and *kali clorua* (content of K_2O is 55-60 %) as a potash fertilizer. The contents and percent in the parenthesis was based on Kha,V.M. (1996).

Average amount of application of chemical fertilizers and manure per unit area is shown in Table 4-3.

Table 4-3. Average amount of chemical fertilizers and manure for rice cultivation in 1998

	Spring	Summer	Total
Nitrogen (kg/ha)	281	237	518
Phosphatic (kg/ha)	634	507	1,089
Potash (kg/ha)	127	168	296
Manure (ton/ha)	12.2	7.5	19.7

In general, nitrogen and phosphatic fertilizers and manure were applied more in spring than in summer. Due to no damage by flooding, the amount of fertilizers affected significantly the rice yield. On the other hand, potash fertilizer was applied more in summer than in spring. According to executive staff of the cooperative, rice varieties introduced from China were easily attacked by insects and diseases when there was a potash fertilizer deficiency. If this is true, the applying of a lot of potash fertilizer to protect against insect and disease damage and the limited use of fertilizers to economize by not using unnecessary fertilizers due to flooding are contradictory. Improvement of water management is needed for the efficient application of potash fertilizer.

The relationship between the amount of three chemical fertilizers in Vietnamese dong and the yield of rice is shown in Fig. 4-13. Although it shows that no significant correlation was observed in the total of each year, the yield of spring rice and chemical fertilizers were strongly correlated. The summer-rice yield did not correlated with fertilizers.

Correlation of chemical fertilizers in spring was due to using phosphatic fertilizer. The relationship between the amount of phosphatic fertilizer in the weight and yield of rice is shown in Fig. 4-14. Great application of phosphatic fertilizer affected rice yield in spring. As discussed in the section on rice varieties in the Red River Delta, application of phosphatic fertilizer was a relatively new technique. It was introduced after the introduction of improved varieties from abroad. The farmers are still groping for a proper application method of phosphatic fertilizer. The fact that great application of phosphatic fertilizer affected rice yield shows that the application method can be technically improved and rice yield increased.

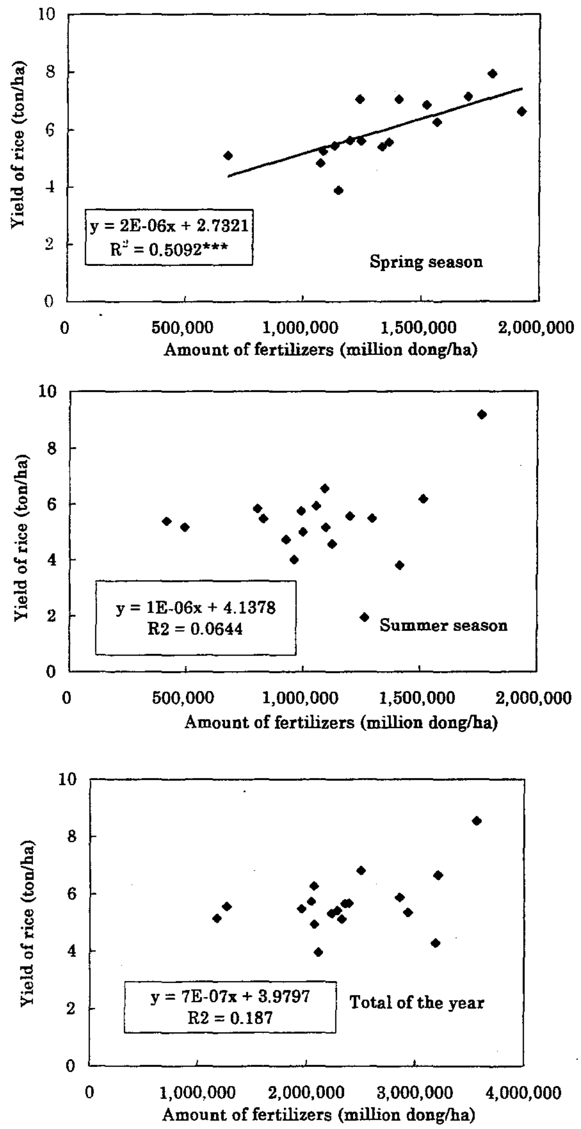


Fig. 4-13. Relationship between application of chemical fertilizers and yield of rice

Note: ***; 0.001 %, **; 0.05 %, and *; 0.01 % (level of significant)

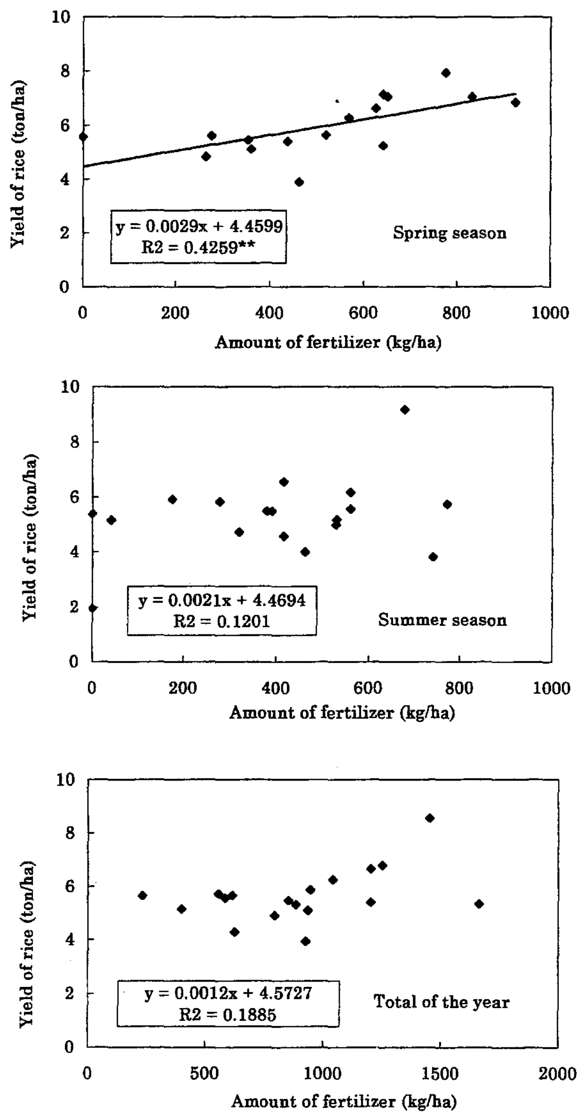


Fig. 4-14. Relationship between application of phosphatic fertilizer and yield of rice

Note: ***; 0.001 %, **; 0.05 %, and *; 0.01 % (level of significant)

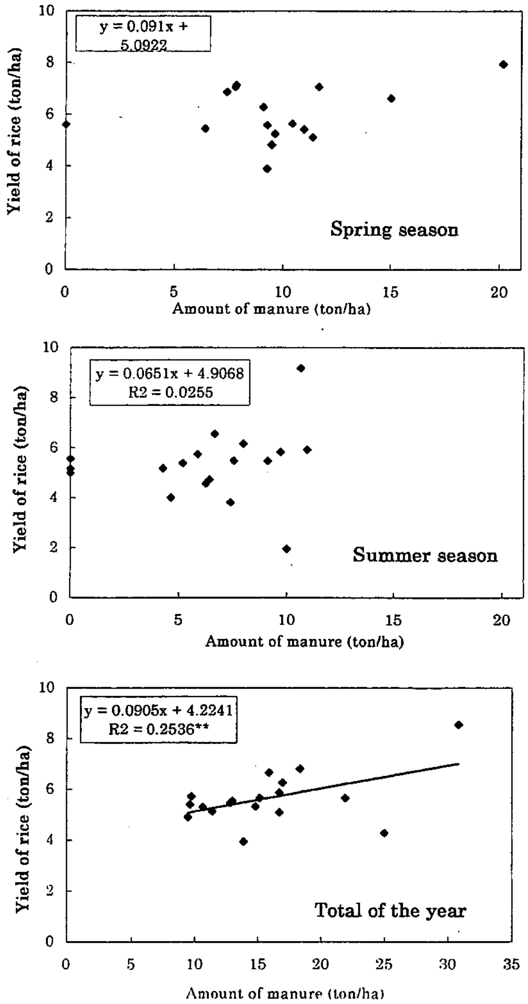


Fig. 4-15. Relationship between application of manure and yield of rice

Note: **; 0.05 % (level of significant)

Regardless of the correlation between chemical fertilizers and the rice yield in spring, no significant correlation between them and the yield of rice in summer was observed. The amount of nitrogen, phosphatic, and potash fertilizers did not correlate with the rice yield in summer. As has been pointed out, one of the determinant factors in changes in the rice yield in summer was flood damage. Flood damage had a probability of two-thirds. As a result, it is considered that great application of chemical fertilizers did not correlate to rice yield. In order to increase the effect of fertilizer application in summer, improvement of rice varieties and water management is needed.

The relationship between the amount of manure in weight and the yield of rice is shown in Fig. 4-15. Correlation was not observed both in spring and summer, but did correlate for the total for the year. Although manure application does not have an immediate effect, it is considered to be an important factor in yearly rice yield.

4.4.2.5. Weeding and intertillage

Weeds were removed by hand and hoeing. Special tools were not used. Herbicide was not used at all. After two weeks of transplanting, the first weeding was done. After this, farmers weeded whenever it was needed. Average working hours for weeding including intertillage were 405 hours 48 minutes/ha, which occupied 12 % of the total. It was the fourth heaviest work among practices, after transplanting, harvesting, winnowing and drying rice.

In contrast to transplanting and harvesting, labor was not exchanged for weeding, because it was enough for farmers to weed gradually when they had the time and the weeds had grown. There was no labor peak for weeding. Working hours for weeding for the spring rice were 247 hours 13 minutes/ha and for the summer rice 158 hours 34 minutes/ha. The former was longer than the latter. It was considered that the reason was the difference in rice variety. The main variety in the spring rice was *ai 32*, which was cultivated in a nursery beds called *ma nen* and transplanted when the height was 5-10 cm. Even though harrowing and leveling before transplanting was done carefully, the spring rice plants competed with the weeds. On the other hand, the main variety of summer rice was *tap giao*, whose height was more than 30 cm at transplanting and the initial growth was also vigorous. Compared with *ai 32* in spring, therefore, *tap giao* did not need much time for weeding. This was considered to be the reason for the difference in working hours for weeding between spring and summer.

4.4.2.6. Insecticide and herbicide application

Disease and insect control was also an important practice during the crop season. In general, frequency in outbreaks of diseases and insects in summer was more than in spring. CT had a disease and insect-forecasting brigade (*doi bao ve thuc vat*), which consisted of 5 members in 1996. They forecasted outbreaks of diseases and insects and gave farmers information, including not only about outbreaks but also the type and amount of agricultural chemicals and time to spray. Farmers purchased agricultural chemicals and spray by themselves.

The main diseases and insects which have broken out in CT in recent years were, rice blast (*dao on* in Vietnamese, due to *Pyricularia oryzae*), sheath blight (*kho van* in Vietnamese, due to *Thanatephorus cucumeris*), bacterial leaf blight (*bac la* in Vietnamese, due to *Xanthomonas oryzae*), the yellow stem borer (*duc than* in Vietnamese, due to *Scirpophaga incertulas*), *Cnaphalocricis medinalis* (*cuon la* in Vietnamese) and other. In 1998, the rice was damaged by sheath blight, the yellow stem borer, and *Cnaphalocricis medinalis*.

Besides by diseases and insects, rice was damaged by rodents all over the country in 1998. Rice in CT was also damaged. Farmers in CT used rodenticide both for the spring and summer rice.

The average amount of agricultural chemicals used was 525,106 dong/ha (Table 4-4). The difference between the maximum and minimum of 18 fields was more than 10 times. Application in summer was more than in spring. The frequency of outbreaks in summer was higher than in spring.

Table 4-4. Average application of agricultural chemicals for rice cultivation in 1998

	Spring	Summer	Total
Average (dong/ha)	226,782	298,324	525,106
Maximum (dong/ha)	738,636	945,513	1,570,513
Minimum (dong/ha)	46,296	92,593	138,889
Maximum/Minimum	16.0	10.2	11.3

4.4.2.7. Harvest and carrying

The rice was harvested all at once. A lot of the labor was done by labor exchange. The reaping of the spring rice was started before dawn in order to avoid the heat of the day. The summer rice was started after sunrise. The starting time was, however, actually flexible. Reaping was begun from the windward side because the tips of the rice touched human eyes, who were reaping, if it was done from the downwind side.

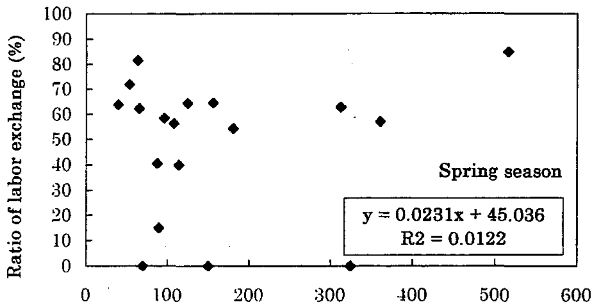
The reaping was done by sickle (*liem*). At first, one farmer reaped the rice plants at the ground level, bundled them and put them down on the ground. Another farmer cut the rice plants on the ground into two using a long sickle (*liem dai*). The half of the rice with the panicles was carried back to house to thresh. The straw after threshing was called *rom* in Vietnamese and used for animal feed. The other half of straw was called *ra*. If the *ra* was wet, it was stood on the ground and dried for several days in the field. If not wet, it was brought to house and piled up. *Ra* is at present used for fuel and feed for animals. It was also used for roof thatching and sleeping mats. CT farmers, however, were using rice straw less because grass, vegetable wastes, and rice husk were preferred as animal feed at present, and furthermore, farmers were using tiles for roofing. The demand for straw was decreasing.

The harvesting season started from the middle of June for spring rice and from the middle of October for summer rice. The difference between the earliest and the latest harvest was about one month, depending on variety. This is to not concentrate the harvest season at one time, as well as for transplanting.

Working hours for the harvest includes that of harvesting and carrying. The percent of harvesting was 22 % of the total. It was the second hardest practice after transplanting. Although working hours by season showed that spring rice needed longer working hours than summer rice, the difference was not significant.

Labor for harvesting and carrying was, in most cases, provided through labor exchange, as well as for transplanting. Owners of 15 fields, both in spring and summer, got their labor from relatives. The other owners provided their own labor. The ratio of working hours by labor exchange to the total working hours for harvesting was 52 % for spring rice and 50 % for summer rice. Harvesting depended more on labor exchange than transplanting.

Ratio of working hours for harvesting by labor exchange differed between fields. Figure 4-16 shows the average ratio of labor exchange to the total working hours for harvesting. As same as the tendency of transplanting, the amount of labor in a household was not a determining factor for the ratio of labor exchange of the working hours.



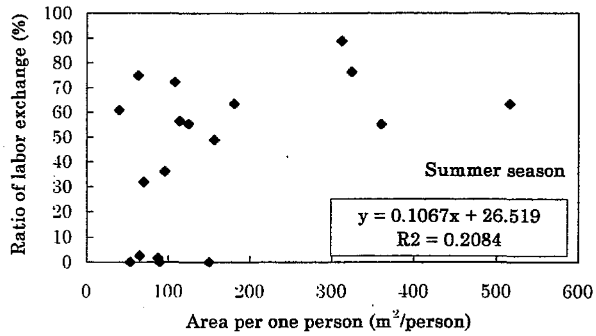


Fig. 4-16. Relationship between ratio of labor exchange of the total working hours for harvesting and area per person

4.4.2.8. Threshing, drying, winnowing, processing, and storing

After harvesting, the rice was immediately threshed by machine. Although rice is threshed by machine at present, threshing by a foot thresher and a stone roller existed in the village before the 1990s. In December 1997, there were 9 threshing machines in CT. All were owned by individuals, and purchased in the Nam Dinh and Xuan Thuy districts after 1990. The price was 4-6 million dong per machine. The cost of threshing was 5000 - 6000 dong/*sao* (139,000 - 167,000 dong/ha) both in spring and summer. Although the cost depends on rice conditions, such as wet or dry, the difference was not so big between them.

After threshing, the unhulled rice was dried on the road and vacant land for several days. If the weather conditions were good for drying, it took 2-3 days for drying. Glutinous rice dried faster than non-glutinous rice.

After drying, the rice was winnowed to remove dust and straw. The rice was then put in a basket made of bamboo, with a diameter of 50 cm and depth of 20 cm, and dropped from the height of a person's shoulder into a flat basket on the ground. At that time, the dust and straw were blown off with an electric fan or a fan made of bamboo from behind. Then, someone shook the flat basket back & forth and left to right to remove the dust and straw one more time.

These processes were repeated twice for winnowing. After winnowing, the unhulled rice was packed in a sack and stored in a well-ventilated room. Theré was no special storehouse for rice.

The working hours for threshing, drying, winnowing, processing, and storing are shown in Table 4-2. Drying and winnowing needed more labor than the others. The ratio of the total working hours for a series of practices from harvesting to storing was 40 %.

4.5. Intensification of rice production: Analysis of land, labor, and capital intensification

4.5.1. Land intensification

Using a simulation model to estimate the yield and rice growing period based on climatic conditions, especially temperature and sunshine duration, double cropping of rice was founded to be inevitable in the Red River Delta, unless a variety with a short growing period was introduced. It was determined, therefore, that land intensification of rice cultivation in Types 5, 6, 7, and 8 had reached the limit. In the fields of Types 1, 2, and 3, where rice was planted once or never every year, rice was not planted because there was not enough water to grow rice in the spring season due to the location being in a high elevation and the fields having sandy soil. In fields of Type 4, it was true that spring rice could be planted but the area was quite small. In terms of landuse rice cultivation, it was impossible to further intensify.

4.5.2. Labor intensification

Working hours for rice-cultivation practices were already shown in Table 4-2. Working hours for rice cultivation were 930 hours 15 minutes/ha in spring and 578 hours 39 minutes/ha in summer. The total working hours were 508 hours 54 minutes/ha.

The area planted in 1996 was estimated to be 169.8 ha of spring rice and 185.2 ha of summer rice (see Chapter 3). Thus the working hours needed for rice cultivation can be estimated as follows:

$$1{,}930.25 \text{ h/ha} \times 169.8 \text{ ha} + 1{,}578.6 \text{ h/ha} \times 185.2 \text{ ha}$$
$$= 327{,}756.45 + 292{,}365.98$$
$$= 620{,}122.43 \text{ hours } (620{,}122 \text{ hours } 26 \text{ minutes}).$$

The population of CT was 3,742 in 1997, out of which, the agricultural population whose main economic activity was agriculture was 3,656 and agricultural labor was estimated by the cooperative to be 1,586. The total working hour for rice cultivation per total agricultural labor, therefore, were

$$620{,}122.43 \text{ hours} / 1{,}586 \text{ persons} = 391.0 \text{ hours/person/year.}$$

If farmers work for 8 hours per day, they will have to spend 49 days for rice cultivation. This shows that it is difficult to evaluate labor intensification through a comparison of the total working hour s year because it will never reach the limit. Rather, a labor peak in a short period can be a limiting factor on rice production, including the cropping system and scale of the land. As shown in Table 4-2, the most labor-required practice was transplanting, especially in the summer season because the area planted with summer rice was larger than for spring rice. Transplanting of the summer rice was the hardest practice of the year.

Transplanting of the summer rice required leveling (harrowing), water management for transplanting, application of basal dressing, pulling of rice seedlings, carrying the seedlings to the paddy fields, and transplanting. Supposing that plowing and harrowing takes one third of the total working hours for plowing and harrowing, which was 33 hours/ha, and levee building took 46 hours 54 minutes/ha, transplanting 408 hours 11 minutes/ha, and application of fertilizer half of the total, which was 71 hours 14 minutes/ha, the total working hours for transplanting in the summer season were 559 hours 19 minutes/ha. The area planted was 185.2 ha. The total working hours for transplanting were 103,585 hours. The total working hours for transplanting per person in CT, therefore, were

103,585 hours / 1,586 persons = 65 hours 19 minutes/person.

Supposing that the limit of working hours for transplanting was 8 hours per day, all the CT agricultural laborers would have to work 9 days to finish transplanting.

According to the recording survey of 18 fields, the period of transplanting of the summer rice in 1998 was 8 days from July 11 to July 18. According to interviews in 1997, it was 7 days from July 6 to 12. The reason why farmers had to transplant in the middle of July was to prevent damage by cold in spring and by flooding in summer. Judging both from the working hours required for transplanting and agricultural labor situation in CT, it is almost impossible to shorten the period of transplanting using the present rice cultivation techniques. Expansion of the rice cultivated area in summer causes an increase of paddy fields where transplanting is done after the middle of July. As a result, there is a possibility of damage by September flood increasing.

The above is an estimation for summer rice. On the other hand, it is considered that the working hours for any agricultural practice were not a limiting factor for expanding the areas of spring rice. It was technically possible.

4.5.3. Capital intensification

An evaluation of the capital intensification in a village level should be required to find determinant factors on the intensification. In order to do that, it is needed to understand the relationship between capital inputs per unit area and the final yield. This is because farmers determine the amount of inputs on the basis of their rational reasons, and, through the analysis of the determinant factors, it is possible to evaluate the effects of capital intensification on the agricultural system in a village.

Inputs to the fields for the double cropping of rice were: chemical fertilizers, manure, agricultural chemicals, and labor. Table 4-5 shows the correlation between them and the yield of rice.

The total yield of rice in 1998 significantly correlated to manure application. Although chemical fertilizers did not significantly correlated to the yield, a higher correlation was observed for it than for the other inputs.

Fertilizers relatively correlated to the yield of rice as a whole.

In the spring season, chemical fertilizers significantly correlated to the yield of rice. More intensification is possible for the spring rice because more input enables the yield of rice to greater increase.

Table 4-5. Correlation coefficient between rice yield and fertilizers, agricultural chemicals, and labor in 1998

	Total yield (ton/ha)	Spring (ton/ha)	Summer (ton/ha)
NPK[1]	0.432	0.714**	0.254
Manure	0.504*	0.361	0.160
Chemi[2]	0.195	0.084	0.189
Labor[3]	0.176	0.327	-0.237

1) The total amount of chemical fertilizer, including nitrogen, phosphatic, and potash.
2) Agricultural chemicals
3) The total labor input
Level of significance: ***; 0.1 %, **; 1%, and *; 5%

In summer, fertilizers did not correlate to the yield of rice. It is considered that damage both by June and September flood prevents farmers from intensifying the summer rice. Flooding, even low water levels of flooding, takes nutrients from the paddy fields. Frequent flooding is a limiting factor of agricultural intensification for summer rice cultivation. As inputs for summer rice did not reflect the output, further intensification of summer rice was expected to be difficult.

Chapter 5. Vegetable cultivation: Intensification analysis of cash-crop cultivation

5.1. Introduction

In Chapter 3, changes in the cropping patterns based on the physical conditions were described. It was estimated that out of the total agricultural land, 11.9 ha was used for "a vegetable-cultivation area (*dat chuyen mau* in Vietnamese)" where farmers plant vegetables throughout the year to get cash income. These fields were characterized by being located in a higher elevations and having sandy soil. The analysis clearly showed that agriculture in the CT had become markedly intensified and diversified in recent years and this fact was characterized by the expansion of vegetable-growing fields.

This chapter shows the effects of cultivation techniques on vegetable production at both the village and farmer level. In the section on the village level, the author showed the technological reasons why such an expansion of vegetable growing fields was possible in that village. In the section on the farmer level, the author described the present status of vegetable cultivation and evaluated agricultural intensification to discuss the factors which limit the expansion of land for cash crops.

5.2. Effects of cultivation techniques on vegetable production at the village level

In terms of cultivation techniques at the village level, three factors are considered to be important: (1) a stable supply of irrigation water for vegetables, (2) the introduction of new crops and varieties, and (3) the dissemination of new techniques for the planting of rice seedlings.

(1) Stable supply of irrigation water for vegetables

In order to expand the vegetable cropping area, in general, a sufficient amount of irrigation water must be secured throughout the year. Irrigation and drainage management for the Coc Thanh Pumping Station is, however, geared to the cultivation of rice and not to that of vegetable crops. The shortage of water had become increasingly conspicuous from the winter to spring season since the expansion of vegetable cropping. In 1989, the CT purchased three diesel pumps. The capacity of the two pumps was 540 m^3/hr and that of the third one 320 m^3/hr. The pumps were set up at a two-level crossing point of the H1 drainage canal (one of the main drainage canals in CT) running from south to north and the irrigation canal running from west to east in the center of CT. Irrigation to vegetable fields from the H1 drainage canal through that irrigation canal was carried out at least 3 to 4 times in a season. Farmers carried the water using a pole from the canal to their own vegetable fields.

The volume of water kept in the H1 canal, however, was not sufficient to irrigate the whole expanded vegetable cropping area. In 1994, the CT carried out repair work on the H1 drainage canal. It was widened from 6 m to 8m and deepened by 50 cm to over a length of 400 m. The repair improved the drainage ability in the summer season and increased the capacity for storing water for vegetable cultivation in the winter spring seasons as well. Thus, water conditions for vegetable fields were much improved which may have contributed to further expansion of vegetable fields.

(2) Introduction of new crops and varieties

The introduction of new crops and varieties by the cooperative was also one of the major reasons for the expansion of the vegetable-cultivated area. New varieties of some vegetables such as garland chrysanthemum, cos lettuce, stem lettuce, sweet potato, and Irish potato were introduced after 1986. Celery (*Apium graveolens*), onion (*Allium cepa*) and other completely new crops were also introduced at that time. These highly marketable crops or varieties gave the farmers a good incentive to grow vegetables. For example, formerly, there was only one variety of sweet potato, with a growing period of 6 months. After the introduction of varieties that required only a 3-month period of growth, the planted area expanded. In the case of the Irish potato, a new waterlogging-tolerant variety allowed planting in low land areas.

Another example is garland chrysanthemum. In 1985, the '*ta*' variety, with a good smell and small leaves, was planted in the CT. Once the new variety called '*tau*' was introduced the cultivated area expanded rapidly. Although the smell of the new variety was not so pleasant, it had a large leaf, and was easy to grow and more profitable. Some years later, when many vegetables were being sold in the market, the old variety was reconsidered for its value, and it became more profitable than the new one. People seemed to prefer the garland chrysanthemum with a good smell to the plant with large leaves.

(3) Dissemination of planting method for young seedlings

There is a method of raising rice seedlings, which is designated as *ma nen* or *ma san* in Vietnamese (see the section 4.4.2.3.). Although this technology was introduced in CT in the latter half of the 1970s, it was only possible to prevent low temperature damage by planting early maturing varieties in those days. The cooperative did not adopt this method at that time because it required more labor. After Resolution 10 was promulgated in 1988, which distributed land to the farmers, people used *ma nen* in their own fields. At the same time, in relatively higher fields where rice double cropping was introduced in 1985, farmers started to adopt multiple cropping in the fields of Types 5 and 6. During the period between October and January, after the harvesting of summer rice and before the transplanting of spring rice, winter crops, such as potato, kohlrabi and leafy vegetables were planted. If it is possible for farmers to sell their vegetables and if they have enough labor to grow them, it is more profitable to have a larger cultivated area. In order to expand the vegetable-planted area, the spring rice cropping period was shortened and the frequency of vegetable planting was increased. Under these conditions, *ma nen* has become widespread since 1988. This is not only because seedlings grown by *ma nen* are tolerant to low temperatures, but also because the growing period of the seedlings is shorter than in the conventional method, so the farmers can delay the planting of seedlings of spring rice by about one month and extend the vegetable-growing period.

As will be discussed later, vegetable cultivation in CT is spatially and temporally sophisticated and intensified. It is true that CT had advantages for developing vegetable cultivation such as natural conditions, a market, and so on. Is it possible, however, for all the cooperatives to expand vegetable areas like CT had, under similar conditions?

Before land was allocated in 1988, in general, farmers in the Red River Delta were able to use a small portion of the land, called 5 % land, (belonging to peasant households), in addition to Government owned and allocated contracted land. Even though they had to cultivate the contracted fields and pay the agricultural products to the Government, they were freely able to grow additional crops for home consumption on the 5 % land. They got about half of their cash income from the 5 % land, although it was only a small fraction of the total land (Murano 1986). It is clear that there was good incentive for farmers to grow crops on the 5 % land.

Assignment of the 5 % land for rice paddies, vegetables, or other crops differed from cooperative to cooperative. In CT, all of the 5 % land was concentrated around residence areas, and vegetables were planted there for home consumption.

For example, in the contracted fields (belonging to Government) of Trang Liet cooperative, which is 15 km northeast of Hanoi, 68 % of the total land is the first category of the land and is planted with spring rice, the summer rice, and vegetables (Iwai 1996: 96). It may only be a coincidence that vegetables cultivation was formally practiced on the 5 % land and that the cultivation area was expanded after land distribution. It is, however, not surprising that the farmers were able to gain technical knowledge of vegetable cultivation methods before 1988 on the 5 % lands on which the farmers grow crops actively on their own.

5.3. Effects of cultivation techniques on vegetable production at the farmer level

Four vegetable-cultivation fields, which are geographically scattered in CT, were chosen for description of cultivation techniques and analysis of agricultural intensification (Fig.5-1). The owners of four fields were different. The authors calls these four fields Field A, B, C, and D, respectively, based on the order of the profit per unit area.

CT farmers usually have 1-2 vegetable cultivation fields for planting vegetables throughout the year. The owner of Field B had only this vegetable-cultivation field as his agricultural land. The other three owners had one more vegetable-cultivation field besides the field of this study.

The average area of the four fields was 133 m^2/household. The maximum area was 240 m^2/household and the minimum was 72 m^2

/household (Table 5-1). The average area of the vegetable-cultivation fields in CT was estimated to be 116 m^2/household.

The number of household laborers for the four fields was two to four. Besides household laborers, they did not hire or exchange extra labor throughout the year.

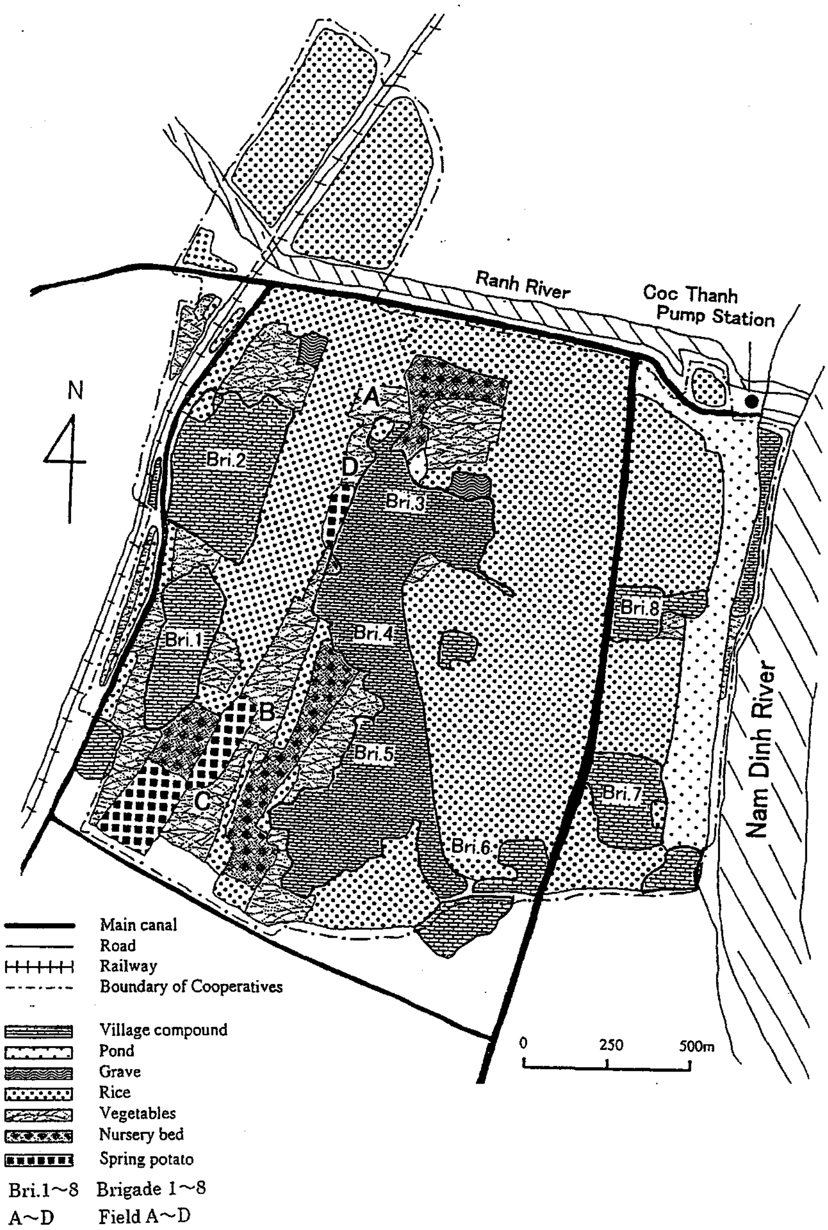


Fig. 5-1. Location of the four sample fields and landuse in the early spring in CT

Table 1 Vegetable cultivation area and household workers

	A	B	C	D
Area (m^2)	120	240	101	72
Workers	2	4	3	3
Gender and age of members	male (35), female (30)	male (39), female (37), female (13), female (12)	male (54), female (47), female (17)	male (44), female (44), male (18)

The authors asked the farmers to record all their agricultural practices in their fields everyday throughout the year. The recording period was one year from 1st March 1998 until the end of February 1999. Research items were: (1) the type, amount, place where purchased, and the price of chemical fertilizers and agricultural chemicals, (2) the water conditions of the field, (3) the working hours by agricultural practice, and (4) the name of the crop, total amount, how it is used, amount for sale, unit price, and where the harvest was sold.

The research members visited CT approximately twice a month to instruct the farmers in how to record their data, and to check the data.

5.3.1. Cropping patterns

All the crops cultivated in the four fields were leafy vegetables. The total number of crops was 12 (Table 5-2). Figure 5-2 shows the cropping period and the total harvesting area of all the crops. The total harvesting area in the Fig. 5-2 means the area which sums up the harvested areas by crop. The main cropping period of Joseph's coat amaranthus, tossa jute, welsh onion, water-convolvulus was summer, and that of garland chrysanthemum, celery, cos lettuce, lettuce, dill, coriander, Chinese cabbage, and rape was autumn-winter-spring.

In addition to vegetables, upland rice nurseries were seeded in June and July in Fields A and B. This is because upland nurseries in higher elevations can avoid flood damage caused by heavy rainfall. The owners of Fields C and D made nursery beds in the fields near residences and other upland fields.

Although the number of crops by field differed, that is, 10 crops in Fields A and B, 8 in Field D, and 3 in Field C, the main crop by season was the same. Lettuce was planted in the autumn-winter and Chinese cabbage in spring. The main crop in summer was tossa jute and water-convolvulus in Field A and welsh onions in the other three fields.

The total number of crops in the year did not relate to the final profit per unit area of the field. This is partly because leaf vegetables with short growing period were repeatedly cultivated, and, as a result, the total working hours for cultivation did not significantly differ among the four fields in spite of the number of crops, and, as will be discussed later, partly because the final profit was related to the unit price when it was sold.

Table 5-2. The vegetables in the four fields

Vietnamese name	English name	Latin name	Area*
rau den	Joseph's coat amaranthus	*Amaranthus tricolor* L.	214
day	Tossa jute	*Corchorus olitorius* L.	146
hanh	Welsh onion	*Allium fistulosum* L.	1408
rau muong	Water-convolvulus	*Ipomoea aquatica* Forssk.	118
cai cuc	Garland chrysanthemum	*Chrysanthemum coronarium* L.	205
rau can tay	Cerely	*Apium graveolens* L.	24
diep	Cos lettuce	*Lectuca sativa* L. longifolia group	54
xa lat	Lettuce	*Lectuca sativa* L. capitata group	1014
thia la	Dill	*Anethum graveolens* L.	30
rau mui	Coriander	*Coriandrum sativum* L.	173
cai thia	Chinese mustard	*Brassica campestris L.. chinensis* group	1469
cai sen	Rape	*Brassica campestris* L. oleifera group	120
ma	(Rice seedling)	*Oliza sativa* L.	184

*: The total harvest area (m^2)

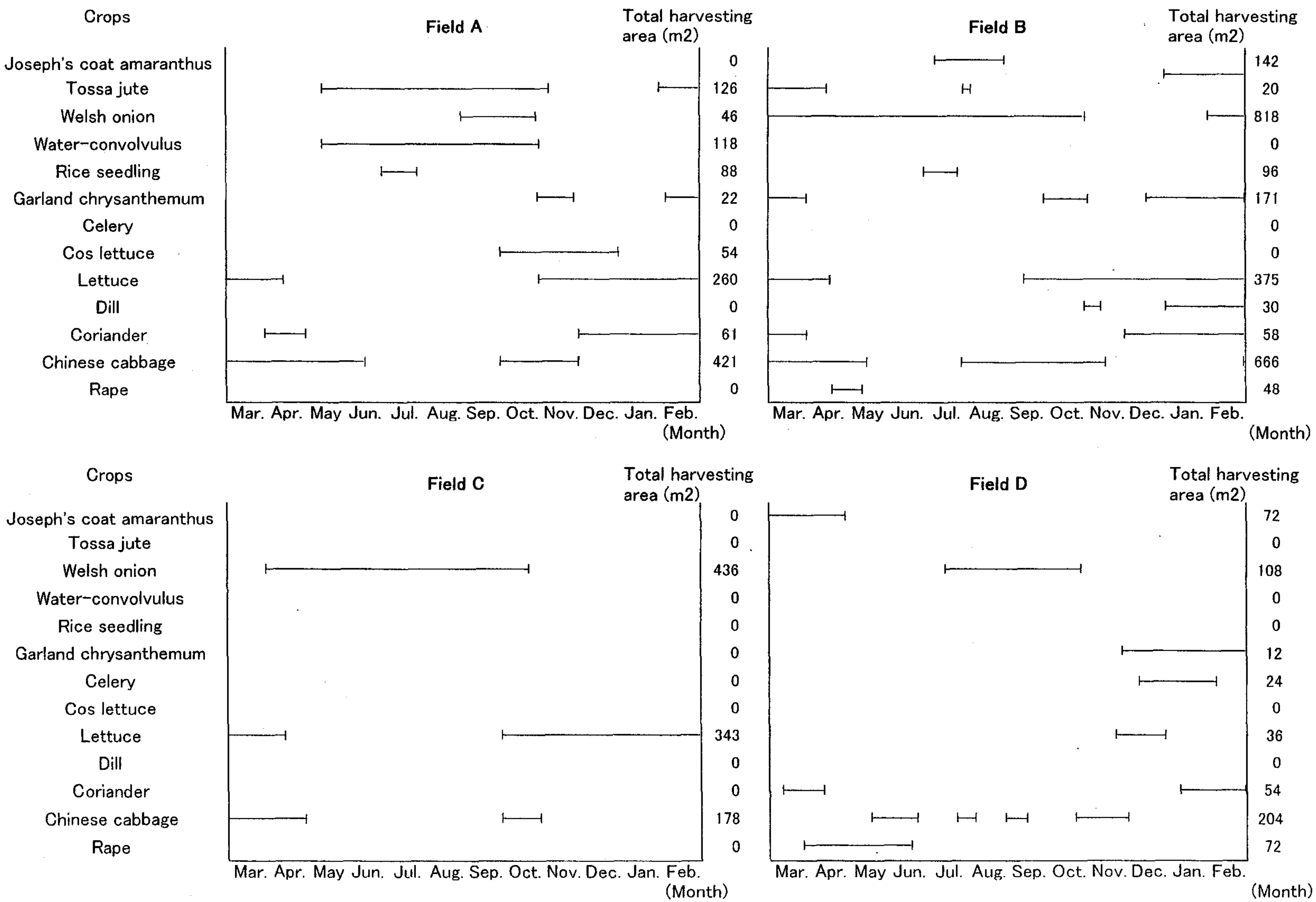


Fig. 5-2. Cropping patterns of the four fields

Cropping intensity of the four fields, which was determining by dividing the total harvesting area by the field area, was 9.7 on average, 10.0 in Field A, 10.1 in Field B, 9.5 in Field C, and 8.1 in Field D, respectively. This index shows that mass production with a small number of crops such as in Field C did not significantly affect the cropping intensity. This was also because short-term growing vegetables were repeatedly cultivated and harvested even in fields with mass production and a small number of crops.

Even though the growing period of leafy vegetables was short, it was difficult to increase the number of harvests under the condition in which the land was used as intensively as a cropping intensity of 10, because the surface area of the field was almost completely occupied by crops throughout the year.

In order to evaluate the spatial and temporal usage of the field by crop in a year, the author defined the occupation ratio, which was formulated as the following expression:

$$\{(\text{planting area} \times \text{planting day}) / (\text{field area} \times 365 \text{ day})\} \times 100$$

For example, if rice with a 4-months growing period is planted twice in the whole area of the field, the occupation ratio of rice is:

$$\{(\text{planting area} \times 8 \text{ months}) / (\text{field area} \times 365 \text{ days})\} = 67\ \%$$

The occupation ratio of vegetables by field in this study was 84 % in Field A, 88 % in Field B, 92 % in Field C and 80 % in Field D. Except for Field D, farmers did not leave any area unplanted for more than one month. This shows that it was quite difficult to increase the number of crops. Judging from the spatial and temporal arrangement of cultivation crops, the vegetable cultivation in CT was intensified to the limit.

5.3.2. Cultivation

5.3.2.1. Planting methods

All vegetables were transplanted once or a few times, after sowing. Joseph's coat amaranthus, tossa jute, welsh onion, coriander, cos lettuce, and water-convolvulus were transplanted once after sowing. The planting distance was, for example, 20 cm × 20 cm for welsh onions. Necessary parts were harvested when the crop had grown up. Garland chrysanthemum, celery, lettuce, dill, Chinese cabbage, and rape were transplanted once or a few times after sowing.

The main cropping pattern in the four fields was single cropping. Mixed cropping of 2 crops was usually observed. More than 2 crops were seldom mixed. The mixed cropping of 2 or more crops made agricultural practices troublesome, because leaf vegetables had a relatively short growing period.

Although all crops could be mixed, two types of mixed cropping were mainly observed. One type of planting was a mixed cropping of vegetables with different growing stages, and the other was that of the single-transplanting of vegetables with the multi-transplanting ones. The former was seen in Fields C and D, where a small number of crops was repeatedly cultivated. The latter was seen in Fields A and B, where many kinds of crops were cultivated. In both types of mixed cropping, different crops in terms of light-intercepting characteristics were mixed in a field. This enabled landuse to be effective without light competition.

Vegetable seeds, including new crops and varieties, were raised by the farmers themselves in their fields and home gardens near their residences. As the cropping season was coming to an end, farmers transplanted some vegetables to raise seeds in a corner of their fields and home gardens.

5.3.2.2. Irrigation

Although drainage was not needed for vegetable cultivation due to the fields being in a high elevation and having sandy soil, irrigation was the hardest work among agricultural practices, taking 32 % of the total working hours (Table 5-3). This was partly because the vegetables in CT were mainly leaf vegetables. Farmers carried irrigation water on a pole with two 10-liter watering pots at the ends. The water source was the drainage canal and ponds. If there was little water in the drainage canal nearby, farmers had to bring water from more than 100 meters from the water source to the field.

Table 5-3. Working hours by agricultural practice

	Field A	Field B	Field C	Field D	Average
Area (m^2)	120	240	101	72	133
Working days (day/person)	268	297	222	173	240
Working hours (hour:minute/person)	516:17	947:00	368:00	293:00	531:04
Average working hour per labor day (hour/day/person)	1:55	3:11	1:39	1:41	2:12
Average working hour per one square meter (hour/m^2/year/person)	4:18	3:56	3:38	4:04	3:59
Ratio of working hour by practice (%)					
Irrigation	15.6	38.5	43.8	25.0	32.0
Plowing and ridging	4.7	7.3	6.0	6.8	6.4
Planting	7.9	9.8	12.0	11.3	9.9
Application of fertilizers (including carrying)	5.5	4.4	6.8	5.3	5.2
Thinning, shielding, and training	1.4	3.9	3.1	5.7	3.4
Weeding (including intertillage)	1.2	3.3	3.3	6.6	3.2
Application of insecticide (pest control)	1.1	0.3	0.5	1.3	0.7
Harvest (including pulling of rice seeds)	31.8	22.7	17.5	17.9	23.4
Processing (including washing)	0.1	3.8	0.0	11.2	3.3
Sale	30.7	5.9	6.8	9.0	12.5
Total	100.0	100.0	100.0	100.0	100.0

In 1989, CT purchased diesel pumps to lighten the irrigation work of the farmers. Irrigation from the main drainage canal to the secondary and tertiary canals was carried out 3 to 4 times in winter to spring (see the section 5.2.).

5.3.2.3. Fertilizer application

(1) Chemical fertilizers application

Urea, a nitrogen fertilizer, and P_2O_5, a phosphatic one, were applied (Table 5-4). Potash fertilizer, which was applied in paddy fields in CT, and other type of fertilizers were not used for vegetables at all. Urea was applied to all the vegetables, except for dill which was only in a small area. It was dissolved in water and irrigated to promote the growth. The average amount of urea application was 2,047 kg/ha. The minimum was 986 kg/ha in Field D, and the maximum was 2,861 kg/ha in Field C, in which the difference was 2.9 times. The amount of urea application was different among crops. The application to 3 major crops occupied 87 %, of which 46 % to welsh onion, 24 % to lettuce and 17 % to Chinese cabbage.

Figure 5-3 shows the monthly application of urea. There were several methods of urea application. In Field B, a certain amount of urea was continuously applied to all the crops. In Field C, the amount of urea was different from month to month. May and November were the two peaks of application in the year, the objective of which was usage in the expanded areas with welsh onions during the May peak and for lettuce during the November peak.

The average amount of P_2O_5 application of the four fields was 1,463 kg/ha (Table 5-4). Phosphatic fertilizer was not used in all the fields. In Field D, it was not used at all. Both in Fields B and C, it was applied to welsh onion, and the application season was from May to September and from March to October, respectively.

Table 5-4. Application of chemical fertilizers, manure and agricultural chemicals

	Field A	Field B	Field C	Field D	Average
Area (m^2)	120	240	101	72	133
Amount of fertilizer application per ha (kg/ha)					
UREA	2,092	2,000	2,861	986	2,047
P_2O_5	250	771	5,594	0	1,463
Manure	44,750	45,833	54,554	53,056	48,218
Cost of fertilizer application per ha (dong/ha)					
UREA	4,697,500	4,350,000	6,329,703	2,172,222	4,509,193
P_2O_5	242,500	847,917	6,153,465	0	1,602,439
Manure	7,947,500	7,791,667	9,274,257	9,019,444	8,273,546
Total of fertilizers	12,887,500	12,989,583	21,757,425	11,191,667	14,385,178
Cost of chemi.*	1,862,500	306,250	77,228	959,722	701,501
Total	14,750,000	13,295,833	21,834,653	12,151,389	15,086,679

* Cost of agricultural chemicals per ha (dong/ha)

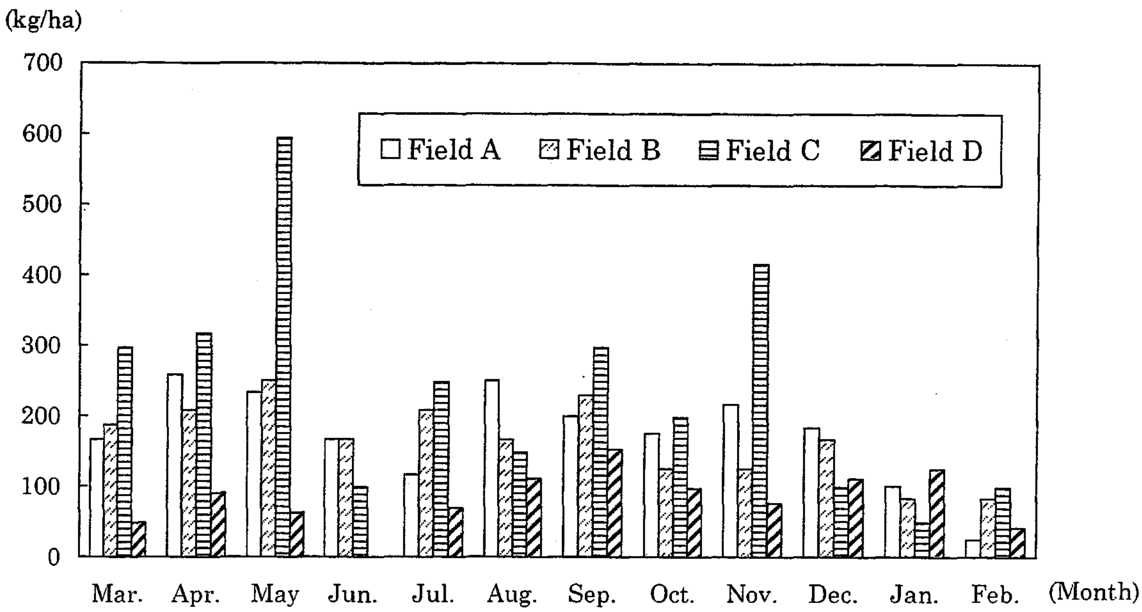


Fig. 5-3. Monthly application of urea in CT

Although the time when the application of phosphatic fertilizer for vegetables was started in CT is not clear, the increase of application was, according to interviews, parallel with the expansion of the vegetable cultivation area during the last decade. The amount of application rate was not fixed because the effect of the phosphatic fertilizer was not so clear for farmers yet.

The price of chemical fertilizers was not fixed throughout the year. The price of urea fluctuated between 2,100 and 2,500 dong/kg (100 dong ≒ 1 Japanese yen ≒ 0.8 US dollars in 1998), and phosphatic fertilizer between 970 and 1,100 dong/kg. Farmers purchased the chemical fertilizers at the shop managed by CT, the local market, or the seed company agencies along the road to Nam Dinh. They decided where to purchase the chemical fertilizers on the basis of how far the fertilizer shops from their residences were, as the price difference between the shops was not significantly great.

(2) Manure application

A mixture of pig and water buffalo dung and rice straw, night soil, and ash from a kitchen range dissolved in water were used as manure for vegetable cultivation. Although 6 kg of a kind of soil conditioner called *phan vi sinh* in Vietnamese was used in Field A, the farmers in the other fields did not use it. Farmers provided the manure themselves. They carried it from their residence to the field by cart and a pole with buckets.

The annual average of manure application in the four fields was 48 ton/ha. Compared with chemical fertilizers, differences in the amount of manure application in the fields was small, between 45 and 55 ton/ha.

The monthly application of manure was different by field (Fig. 5-4). In Field B, manure was constantly applied, and the maximum amount of manure was 6.3 ton/ha in November and the minimum 1.5 ton/ha in January.

In Field C, on the other hand, the maximum was 13.4 ton/ha in May, and the minimum was 1.0 ton/ha in November and February. The application in May was to expand the welsh onion area, and also the urea application.

As seen in Table 5-4, there was no correlation between the amount of chemical fertilizers and manure, and the final profit per unit area[1]. Both Figs. 5-3 and 5-4 did not show a correlation between the application method and the profit. This fact, in other words, shows that great use of chemical fertilizers and manure did not result in high profits. The amount of capital invested per unit area, that is, the capital intensity, did not affect the final profit per unit area.

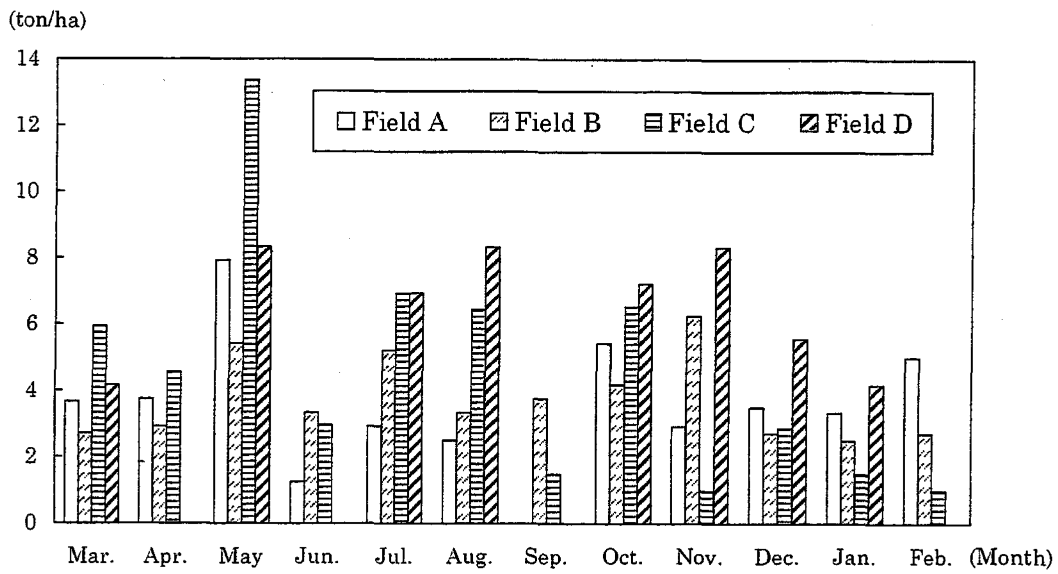


Fig. 5-4. Monthly application of manure in CT

5.3.2.4. Weeding

The average ratio of working hours spent on weeding was 3% (Table

[1] Profit is discussed in section 5.4.

5-3). Weeding was often carried out during plowing, planting, fertilizer application, and irrigation. It is true that actual working hours spent weeding would be more than 3 %, but weeding was not as hard as the other practices.

Weeding was carried out by hand. Herbicide was not used at all. The weeds were less than 5 cm high when weeded because various agricultural practices prevented them from growing. The pulled weeds were left at the side of the field and seldom used as green manure or feed for animals.

5.3.2.5. Diseases and insects control

Agricultural chemicals were used for pest and disease control. Insecticide was mainly used to eradicate green caterpillars. It was sprayed from March to November, especially in great amounts from March to May and from July to September. It was not sprayed from December to February because there was no outbreaks of insects due to low temperatures.

Seven types of insecticide were observed in the four fields during the year. According to interviews, farmers went to the market whenever insects appeared, and purchased whatever agricultural chemicals they found there. They did not use the same chemicals throughout the year.

The average amount of agricultural chemicals per unit area was 701,501 dong/ha. The range of the expense for chemicals by field was between 77,228 and 1,862,500 dong/ha (Table 5-4). As mentioned above, farmers purchased only the necessary amount of chemicals whenever insects outbreaks occurred. The climatic conditions of the four fields were probably the same. Nevertheless, the outbreaks of insects were different from field to field and, therefore, the gap in the amount of agricultural chemicals used was 24 times between the maximum and minimum.

The four fields of this study were continuously planted with vegetables throughout the year at least since the 1970s. It is noted that damage from continuous cropping has not been observed yet. Salt accumulation due to over application of chemical fertilizers has not been observed.

5.3.2.6. Harvesting and processing

(1) Working hours for harvesting and processing

Harvesting and processing were carried out by hand. Harvested vegetables were washed at ponds and canals near the field and residences, and divided into small bundles by using banana or bamboo skins. Lettuce and garland chrysanthemum were divided into bundles of 150 grams, called *bo* in Vietnamese. The average ratio of working hours for harvesting and processing was 26 % (Table 5-3). This was the second highest after irrigation. Harvesting and processing were also hard work because leaf vegetables have a short growing period and farmers have to harvest frequently.

(2) Amount of harvest

Harvests were classified into 3 groups, namely, for sale, for home consumption, and for seeds. Home consumption was classified into 2 sub-groups, one was for people to eat, and the other was for animal feed. Table 5-5 shows that the amount of harvest and the utilization by field. Many harvests were utilized for sale. A small number of crops were used for home consumption and for seeds. In Field A, for example, 4 crops were used for home consumption and only 1 crop for seeds. Seeds of the other crops were planted in the home garden or obtained from others.

Comparison of the harvest by field will be discussed in section 3 because crops differed by field.

Table 5-5. Amount of harvest and utilization

	Field A				Field B				Field C				Field D			
Crops	Harvest	Sale	HC	Seeds	Harvest	Sale	HC	Seeds	Harvest	Sale	HC	Seeds	Harvest	Sale	HC	Seeds
Joseph's coat amaranthus	0	0	0	0	4,896	4,896	0	0	0	0	0	0	10,139	9,028	1,111	0
Tossa jute	20,050	20,050	0	0	1,229	1,229	0	0	0	0	0	0	0	0	0	0
Welsh onion	4,000	4,000	0	0	35,454	35,454	0	0	37,871	33,911	891	3,069	14,306	12,639	0	1,667
Water-convolvulus	19,658	13,117	6,542	0	0	0	0	0	0	0	0	0	0	0	0	0
Rice seedling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Garland chrysanthemum	733	733	0	0	10,554	10,554	0	0	0	0	0	0	0	0	0	0
Celery	0	0	0	0	0	0	0	0	0	0	0	0	3,333	3,333	0	0
Cos lettuce	5,392	5,292	100	0	0	0	0	0	0	0	0	0	0	0	0	0
Lettuce	50,025	45,458	483	4,083	49,313	41,938	7,375	0	65,911	65,614	297	0	13,889	13,889	0	0
Dill	0	0	0	0	625	625	0	0	0	0	0	0	0	0	0	0
Coriander	3,083	3,083	0	0	1,833	1,833	0	0	0	0	0	0	5,000	5,000	0	0
Chinese cabbage	65,000	64,917	83	0	25,163	24,942	0	0	17,743	17,149	594	0	28,236	28,236	0	0
Rape	0	0	0	0	1,375	1,375	0	0	0	0	0	0	8,569	8,569	0	0

Note; unit is kg/ha, HC is home consumption, Harvest = sale + HC + seeds

5.3.2.7. Sale

After harvesting and washing, farmers divided the vegetables into small bundles and carried them by bicycle to the market. There was no farmers association in CT for promoting the selling of vegetables. According to the executive staff of CT, this was because the demand of vegetables was too small to sell them continuously throughout the year.

Farmers in CT sold their vegetables to the merchants at the markets in Nam Dinh, at the local markets, and to middle persons who lived both inside and outside CT. Nam Dinh is the third biggest city in the Red River Delta. It is 7 km from CT and the population was 220,000 in 1994-95 (Que et al. 1996: 127). Many farmers of CT went to sell their vegetables in the early morning. The local markets were managed by the commune in the area and opened daily. The main commodities were daily necessities and perishable foods. The people who sell and buy were nearby merchants and farmers. Thanh Loi commune also had a local market, which is located at the southern boundary of CT.

There were two types of middle persons, some of which were temporary and the others permanent ones. The temporary middle persons were farmers living in CT. They cultivated vegetables by themselves. When they went to the market, they sold their own harvested vegetables and, in addition to these, purchased some vegetables from other farmers. The permanent middle persons regularly came to CT from another villages. They directly contracted with the farmers. Although they purchased vegetables, harvested by the farmers, they sometimes contracted with farmers to harvest crops, wash them, and bring them to the market.

The average working hours for sale was 13%, which was relatively longer than the other agricultural practices (Table 5-3). The ratio of working hours for sale was different among the four fields, especially, that of

Field A whose working hours was exceptional great. Although farmers in Fields B, C, and D sold vegetables at the local market and to middle persons, farmers in Field A went to the market in Nam Dinh by bicycle to sell vegetables themselves.

Leaf vegetables such as lettuce and Chinese cabbage were harvested, washed and divided into bundles in the evening of the previous day of selling. At 3 o'clock in the following morning, they brought the vegetables by bicycle with two baskets, with a diameter of 50 cm and a height of 1.3 m, by walking their bicycles to Nam Dinh. They arrived at the market in Nam Dinh at 5-6 o'clock in the morning, and started selling. They sometimes did not sell all their goods until the afternoon.

On the other hand, farmers in Fields B, C, and D sold their vegetables at the local market and to middle persons. As a result, the ratio of working hours for sale in Fields B, C, and D was 6-9% and Field A was 31%.

5.3.2.8. Working hours

The average working days during the year was 240 days. The maximum was 297 days for Field B, and the minimum was 173 days for Field D (Table 5-3).

The average working hours per one labor day was between 3 hours and 11 minutes for Field B and 1 hour and 39 minutes for Field C. It can be said that more than one hour and less than 2 hours was the average working hours per day for 100m^2 vegetable field.

Comparing the working hours per unit area, or labor intensification, the maximum was 4 hours 18 minutes /m^2/year for Field A, and Fields D, B, and C were lower in this order. Field A spent much time for harvesting and sale. Conversely, Field C did not spend much time for harvesting. The farmers in Field C often contracted with middle persons to sell their vegetables. Different strategy for sale by field affected the working hours spent for harvesting and sale.

The monthly working hours by field is shown in Fig. 5-5. The average working hours in June were few. It was the busiest month of the year in rice cultivation because harvesting of spring rice and transplanting of summer rice overlapped. The average working hours in October were the greatest for the year. It took a lot of time to carry out the planting, irrigation, fertilizer application, thinning, and harvesting, because this was the season to convert the summer crops to the winter-spring ones. Especially for Field C, October was the month of the most working hours during the year. In Field D, it was the second most months after August. In Field D, the working hours for cultivation in August took 59 % of the total working hours for the year. This was because of irrigation work.

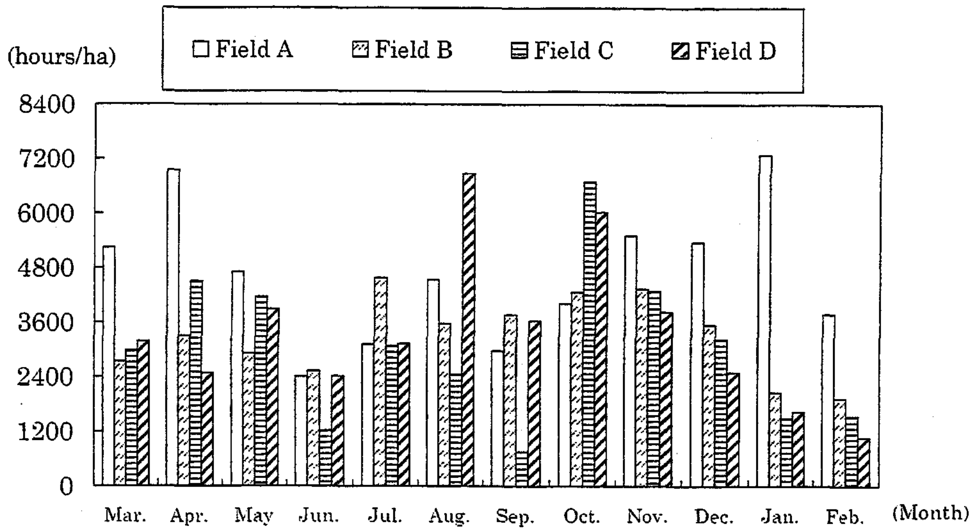


Fig. 5-5. Monthly working hours by field

In addition to this, the working hours of Field A from November to May were great. This was because of the working hours for sale. As mentioned above, farmers of Field A went to the market in Nam Dinh to sell vegetables themselves. The winter, when a lot of vegetables were grown, was a very busy season.

Females spent a lot of working hours on vegetable cultivation. The average working hours of female were 70-80 % of the total working hours. The difference in working hours between males and females showed the same tendency among the four fields. The working hours by agricultural practice showed clearly that the working hour of female was more than half of the total working hours in the almost all the practices. The only exception was the application of insecticide, in which male worked 88-100 % of the total working hours.

Labor intensification of vegetable cultivation should be discussed within the whole farming system, including paddy cultivation, animal husbandry, aquaculture, and other aspects. It is true, however, that labor for vegetable cultivation in CT was not easy, as the farmers took more than 1 hour per day for 240 days of the year. Furthermore, labor intensification did not affect the final profit per unit area. The fact that a high input of labor did not always generate high return showed that labor intensification for vegetable cultivation in CT was already close to the limit under the present conditions.

5.4. Revenues, expenditures, and profits from Vegetables sale

The vegetables raised in the four fields were cash crops. Table 5-6 shows the total sales, unit price, and amount of sale per unit area by crop. Comparison between the quantity (kg/ha) and total (dong/ha) sales showed that mass production did not relate to high revenue, because the unit price fluctuated constantly throughout the year. The unit price of a crop differed by the time of sale, places to sell, and the sellers and buyers. The annual change in the lettuce unit-price at the local market of CT is shown in Fig. 5-6. Lettuce was cultivated many times from the autumn to the next spring. The unit price, therefore, became higher in the summer, because the supply of lettuce was reduced. The maximum unit-price was 1,750 dong/kg on 22 October 1998, and the minimum was 208 dong/kg on 6 March 1998. The annual difference in the lettuce unit-price at the local market was 8.4 times.

Table 5-6. Quantity of sales, unit price, and total vegetable sales

	Field A	Field B	Field C	Field D	Average
Quantity of sale per ha (kg/ha)					
Joseph's coat amaranth	0	4,896	0	10,139	3,574
Tossa jute	20,050	1,229	0	0	5,068
Welsh onions	4,000	35,454	34,802	12,639	25,167
Water-convolvulus	19,658	0	0	0	4,426
Garland chrysanthemui	733	10,554	0	0	4,917
Cerely	0	0	0	3,333	450
Cos lettuce	5,392	0	0	0	1,214
Lettuce	45,942	49,313	65,911	13,889	46,914
Dill	0	625	0	0	281
Coriander	3,083	1,833	0	5,000	2,195
Chinese cabbage	65,000	25,163	17,743	28,236	33,141
Rape	0	1,375	0	8,569	1,777
Unit price (dong/kg)					
Joseph's coat amaranthus		732		792	755
Tossa jute	885	973			894
Welsh onions	1,467	980	1,436	992	1,118
Water-convolvulus	615				615
Garland chrysanthemui	1,000	721			731
Cerely				500	500
Cos lettuce	819				819
Lettuce	782	766	460	600	681
Dill		600			600
Coriander	2,027	1,561		2,514	2,002
Chinese cabbage	510	605	713	770	593
Rape		339		692	569
Amount of sale per ha (dong/ha)					
Joseph's coat amaranth	0	3,583,333	0	8,033,120	2,698,658
Tossa jute	17,741,667	1,195,833	0	0	4,532,833
Welsh onions	5,866,667	34,737,500	49,990,099	12,541,667	28,129,456
Water-convolvulus	12,083,333	0	0	0	2,720,450
Garland chrysanthemui	733,333	7,611,667	0	0	3,592,495
Cerely	0	0	0	1,666,667	225,141
Cos lettuce	4,413,333	0	0	0	993,621
Lettuce	35,923,583	37,749,208	30,337,030	8,333,333	31,960,000
Dill	0	375,000	0	0	168,856
Coriander	6,250,000	2,862,500	0	12,569,444	4,393,996
Chinese cabbage	33,158,333	15,233,333	12,658,713	21,736,111	19,659,531
Rape	0	466,667	0	5,930,556	1,011,257
Total	*116,170,250*	*103,815,042*	*92,985,842*	*70,810,897*	*100,086,294*

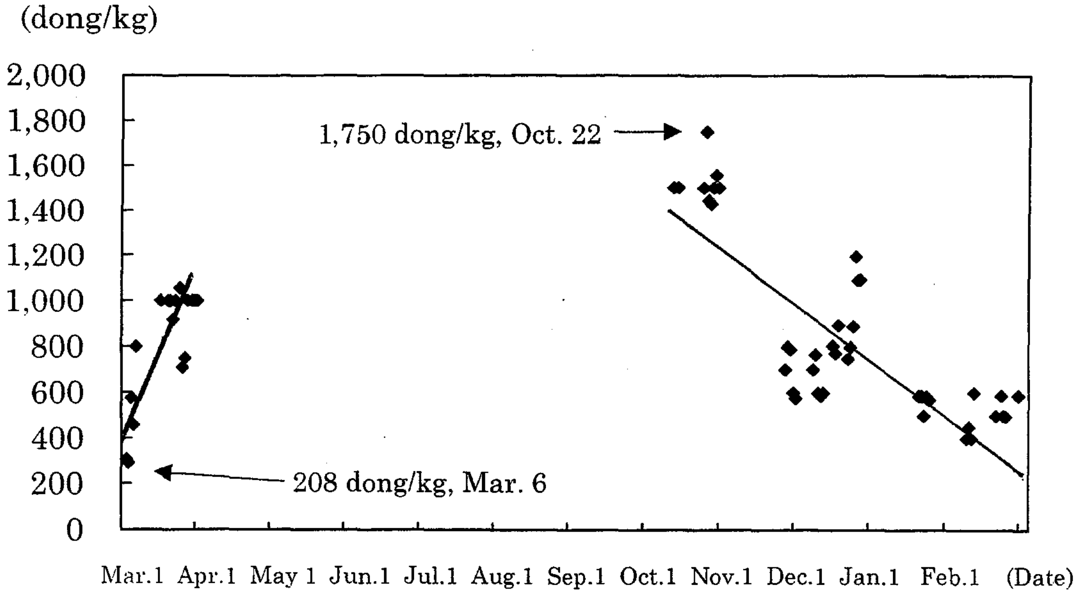


Fig. 5-6. Annual changes in lettuce unit-price at the local market of CT

Unit-price difference occurred according to where crops were sold and bought. The farmers of Field A mainly sold vegetables to the market in Nam Dinh. Field B to the local market, and Field C to middle persons. Field D did not have fixed places or persons at where and to whom they sold them. The unit-price difference of lettuce is shown in Table 5.7. The annual difference in lettuce unit-price at the market in Nam Dinh was 2.1 times, and the farm gate unit-price to middle persons was 8.5 times. The larger the scale of the market was, the smaller the difference in unit-price was and the higher the selling price was.

The difference in unit price occurred for the same crops at the same place in the same season. It occurred between sellers and buyers. At the local market on 30 March 1998, for example, although farmers of Field B sold lettuce for 1,000 dong/kg, the farmer of Field C only for 390 dong/kg. The unit price of the same crop could be different even among the same quality vegetables at the same market in the same day. The unit price was determined by supply and demand in a small-scale market and place. As a matter of course, it was not determined by farmer inputs, such as chemical fertilizers, agricultural chemicals, and labor. A high input of fertilizers and chemicals did not always generate high return. The total sales were closely related to the unit-price.

Table 5-7. Unit-price difference of lettuce by place

	Nam Dinh	Local market	Middle persons
Max price (dong/kg)	1,250	1,750	1,571
Date	Mar./28, 1998	Oct./22, 1998	Oct./24, 1998
Min price (dong/kg)	600	400	184
Date	Feb./1, 1999	Jan./26, 1999, Feb./3, 1999	Feb./1, 1999
Difference (max/min)	2.1	4.4	8.5
Average price (dong/kg)	782	766	460

The farmers' profit from vegetable cultivation was the balance between expenditures and revenues (Table 5-8). Expenditures consisted of chemical fertilizers and agricultural chemicals. Manure has been appropriated to revenues because it was provided by the farmer. The total amount of chemical fertilizers and agricultural chemicals per unit area of the four fields was 6,813,133 dong/ha on average. The maximum was 12,560,396 dong/ha of Field C and the minimum was 3,131,944 dong/ha of Field D, a difference of about 4 times. Expenditures by field did not correlate to the final profit per unit area.

Revenue consisted of manure, wages for working, and amount of sale. The price of manure was assumed to be 170 dong/kg, which was estimated by CT. Wages were equal to the working hours times 7,000 dong/day, which was also estimated by CT. Although the gender and ages of family labor differed among the four fields, wages were fixed and could be calculated. The profit per unit area of the four fields was 136,420,026 dong/ha on the average. The maximum was 154,960,907 dong/ha of Field A, and the minimum was 112,303,036 dong/ha of Field D, a difference of 1.4 times.

The factor related to the final profit per unit area was the amount of sale. The bigger the total sales were, the bigger the profit was. This suggested that how to sell was the determinant factor in the final profits.

Table 5-8. Revenues, expenditures and profits of vegetable cultivation

	Field A	Field B	Field C	Field D	Average
Area (m^2)	120	240	101	72	133
Expenditures (dong/ha)					
Chemical fertilizers	4,940,000	5,197,917	12,483,168	2,172,222	6,111,632
Agricultural chemicals	1,862,500	306,250	77,228	959,722	701,501
Subtotal	6,802,500	5,504,167	12,560,396	3,131,944	6,813,133
Revenues (dong/ha)					
Manure	7,947,500	7,791,667	9,274,257	9,019,444	8,273,546
Wages *	37,645,657	34,526,042	31,881,188	35,607,639	34,873,319
Amount of sale (dong/ha)	116,170,250	103,815,042	92,985,842	70,810,897	100,086,294
Subtotal	161,763,407	146,132,750	134,141,287	115,437,981	143,233,159
Profit (dong/ha)	154,960,907	140,628,583	121,580,891	112,306,036	136,420,026

Note: Profit = Revenues - Expenditures
* This is estimated to be 7000 dong/day.

5.5. Evaluation of intensified vegetable-cultivation

This study focused on vegetable cultivation, one of the main sources of cash income in the rural Red River Delta, evaluating the intensification by analyzing the daily record of four fields of one cooperative. As a result, in terms of the spatial and temporal arrangement of cultivation crops, it was determined that vegetable cultivation in CT was intensified up to the limit. From the viewpoint of capital intensification, which was mainly calculated based on chemical fertilizers and agricultural chemicals, it was found that capital intensification did not correlate to the final profit per unit area. Furthermore, labor intensification for cultivation was already at the limit under the present conditions because a high input of labor did not always generate high profits. These findings, in summary, show that technical intensification does not reflect in the profits.

Technically, however, farmers in CT could expand their vegetable cultivation area judging from the natural conditions (see Chapter 3). Why did they not expand vegetable growing areas? The final profit per unit area did not relate to the agricultural intensification, but did to the unit-price, which resulted in high profits. It was considered that farmers did not have the incentive to intensify vegetable cultivation. If this is true, farmers should try to find better places to sell their goods for a higher unit price.

Farmers, however, did not have many alternatives for deciding to whom and where they sell their vegetables. Farmers of Field A sold at the markets in Nam Dinh, Fields B and D at the local markets, and Field C to middle persons throughout the year. It was a rather fixed situation, although there was a big price difference. This is partly because of lack of information on marketing.

In addition to that, the unit price of vegetables was not stable. It constantly fluctuated throughout the year. Price difference occurred even between the same crops at the same market on the same day. All these things make it clear that the information network and distribution system of vegetables in the rural Red River Delta should be reconsidered in order to expand the vegetable cultivation area.

Chapter 6. Potato production: Fund-raising activities by the cooperative

6.1. Introduction

In the fields of Types 3, 4, 5, 6, and 7, both rice and upland crops were cultivated in 1996. In terms of the natural conditions, cropping patterns in these types were not fixed. For example, the fields in Type 3, where is a buffer zone between the area of vegetable-based cropping pattern and rice-based ones, can be planted with both vegetables and rice. The present cropping pattern is not determined by physical conditions, but by labor force, vegetables market, and so on.

In this chapter, the author focuses on potato production in Type 5 to analyze the effect of socio-economic factors on the cropping pattern, as it was initiated by the cooperative.

The system of agricultural production based on village-level agricultural cooperatives (hereafter called "cooperatives"), which were formed in the late 1950s in the rural areas of North Vietnam, has changed since Resolution 10 (*khoan 10*) was promulgated in 1988. The function of cooperatives, which had planned and controlled production in the villages, was greatly reduced, and the household came to be considered as an autonomous unit of economy (Lam *et. al.* 1992, Tuan 1997). In the late 1980s and the 1990s, nominal cooperatives were scrapped and new cooperatives were created as service organizations to assist farmers (Quy & Nha 1999).

In the process of the changes in cooperatives' function, on the other hand, economic factors have been pointed out to be an important function of cooperatives. For example, Lam et al. (1992) pointed out the importance of cooperatives in commercial economy, and Tuan (1997) asserted that, instead of the Government in the past, new types of cooperatives had to cope with a monopoly from the market economy (Tuan 1997). A new law on cooperatives, which was approved by the National Assembly in March 1996, also promoted the establishment of new types of cooperatives as autonomous economic organizations (Law on cooperatives 1996).

These discussions, however, are too abstract and ideal to be clear about contents of the cooperation. The purpose of this chapter is, therefore, 1) to describe the history and the present cultivation of potato in CT, and 2) to evaluate the economic activities of cooperatives based on an analysis of the actual economic activities.

6.2. Brief history of potato production in CT

6.2.1 Introduction of spring potato

CT has two cropping patterns for potato. One is for winter potato (*khoai tay dong*), which is planted in October and harvested in December-January, and the other is for spring potato (*khoai tay xuan*), which is planted in December and harvested in March. The main crop before the 1980s was winter potato, because there was no good varieties of spring potatoes.

New improved varieties of spring potato were introduced into CT in 1986. Vietnam Agricultural Science Institute (VASI), an agricultural research institute under the direct control of the Ministry of Agriculture and Rural Development, and one non-government organization assisted in this introduction. To promote potato cultivation in the lowland areas of the delta, Dr. Kim, then deputy director of VASI, selected four cooperatives, including CT in Nam Ha Province (Nam Dinh and Ha Nam Province at present) and begun cultivation experiments of spring potato. According to Dr. Kim, CT was selected because it had many fields with sandy soil, had cultivated many vegetables including potato, and was characterized by the strong leadership of the cooperative.

After retiring from VASI, Dr. Kim established an NGO named KVT Project, and, with the assistance of Dutch experts, he continued to introduce excellent potato varieties from Holland into rural Vietnam. CT contracted with KVT Project for spring potato cultivation, and started seed potato production from stock seed potato brought by the KVT Project. As a result, spring potato production was started in CT from 1986.

6.2.2 Land distribution and potato production areas in CT

After the decision to introduce spring potato cultivation, the cooperative held several meetings with the heads and secretaries of the eight brigades in order to allocate land for cultivation. As a result, Brigades 1, 2, 3, 4, 5, and 6 decided to cultivate spring potato in certain designated fields under the direction of the cooperative. Brigades 7 and 8 decided not to cultivate, because they had no fields suitable for spring potato production. According to the executive staff of the cooperative, these fields were chosen for spring potato cultivation because: (1) they had been seed rice fields that were managed cooperatively by several brigades; (2) drainage and irrigation was readily controllable because of the location near canals; (3) the soil was suitable for potato; and (4) it was easy to manage cultivation because the fields were near a residential area.

Based on Resolution 10 of the central government issued in 1988 (*khoan 10*) and on Instruction 115 of Nam Ha Province issued in 1992, cooperatives' land was assigned to farming households for long-term use. A series of agricultural renovation policies during this period brought about a transition from a group farming system to privatization and a market economy. In CT, land was allocated to individual farmers and a land register was drawn up in 1994, when the cooperative decided that potato cultivation should be continued in the designated fields, and the cooperative managed the potato production even though the land was allocated to individual farmers. The designated potato fields were, therefore, allocated to the farmers who had intended to continue potato cultivation. According to the land register of 1994, the average potato area in the designated fields was 120 m^2/household.

Potato cultivation area by brigade is shown in Table 6-1. Although six brigades had potato fields, Brigade 3, 4, 5, and 6 accounted for 80% of the total potato cultivation area managed by the cooperative. The area of these brigades is included in that of the old commune (*xa*) named Bach Coc. Before 1945, CT was divided into three old communes: Bach Coc (5 hamlets), Phu Coc (1 hamlets), and Duong Lai (2 hamlets). From the late 1950s, several communes, including Bach Coc, were repeatedly reorganized, with changes to their administrative boundaries. Eventually, the three old communes formed CT in 1980. When CT began to plant spring potato in 1986, the fields were located in the area of Bach Coc.

In terms of its natural setting, including soil and water conditions, Bach Coc is not the only place that is suitable for potato cultivation. Duong Lai, which corresponds to Brigades 1 and 2 at present, also has suitable fields for potato cultivation. Bach Coc displayed leadership in enclosing the designated fields and promoting spring potato production as an operation of the cooperative.

Spring potato cultivation area and yield in CT is shown in Fig. 6-1. In addition to 5.1 ha of designated potato fields, spring potato was cultivated in 2.5 ha in 1994, 3.9 ha in 1995, 3.2 ha in 1996, 7.5 ha in 1997, and 2.1 ha in 1998. Any farmer can cultivate spring potato if he/she contracts with the cooperative and follows the cultivation method recommended by the cooperative.

Table 6-1. Land allocation of potato cultivation fields in CT

Brigade	Area (ha)	Ratio (%)	Old *xa*
1	0.68	13.3	Duong Lai
2	0.33	6.4	Duong Lai
3	1.23	24.2	Bach Coc
4	0.90	17.6	Bach Coc
5	1.27	25.0	Bach Coc
6	0.69	13.4	Bach Coc
7	0	0	Phu Coc
8*	0	0	Bach Coc

Source: Land register of CT in 1994
* Although Brigade 8 belongs to Bach Coc, it is located along the Nam Dinh River and about 500 m away from the hamlets of brigades 3, 4, 5 and 6. In 1963 and 1966, brigade 8 and 6 formed one cooperative.

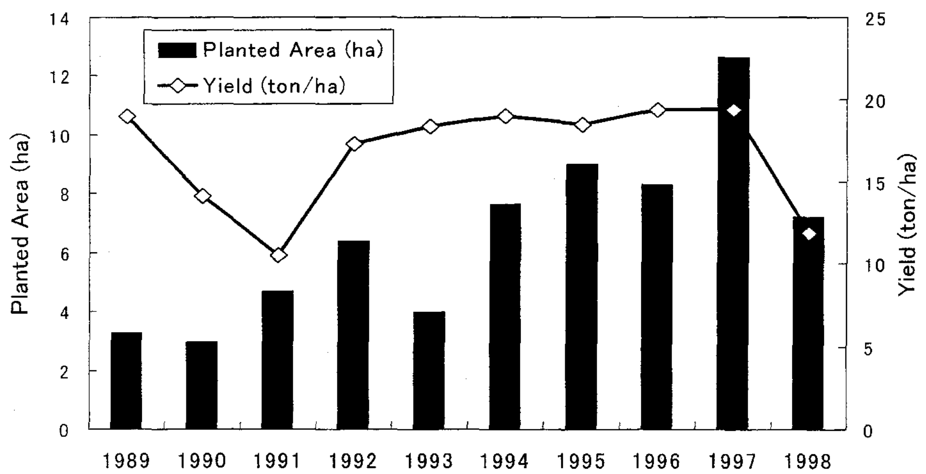


Fig. 6-1. Yield and planted area of spring potato in CT

Source: CT

6.3. Spring potato cultivation, storage, and sale

6.3.1 Contracts

Two types of contracts are employed in potato production. One is between KVT Project and the cooperative, and the other is between the cooperative and farmers. The cooperative plays a key role in the spring potato business, in terms both of contractual arrangement and management.

In the contract between KVT Project and the cooperative, KVT Project provides stock seed potato. After the potato harvest, the cooperative pays back to KVT Project the cost of the stock seed potato and a certain amount of potatoes as service fee.

In the contract between the cooperative and farmers, the cooperative provides knowledge of the cultivation method and a packaged material for potato cultivation, including stock seed potato, chemical fertilizers, and agricultural chemicals. Farmers cultivate seed potato with their own labor and manure, and pay back the cost of packaged material to the cooperative. Although farmers can freely sell the remaining harvest at markets nearby, many of them sell potato on consignment to the cooperative, retaining only what they need for home consumption.

6.3.2 Cultivation

Farmers must follow exactly the cooperative's instructions regarding cultivation method. The cultivation method in 1997 was as follows.

Planting period was 10 - 15 December. Before planting, ridges of 1.2 m in width were raised in the field. Two rows of seed potatoes were planted in each ridge, the interval between rows being 30-35 cm, that between plants 25-30 cm, and the planting density 5-8 plants per m^2.

The total amounts of fertilizers to be applied were 650 kg/*sao* (1 *sao* =

360 m^2, 18 ton/ha) of manure, 12 kg/*sao* (333 kg/ha) of urea, 12 kg/*sao* (333 kg/ha) of P_2O_5, 3 kg/*sao* (83 kg/ha) of K_2O. Manure, a mixture of pig and water buffalo dung, was scattered around field as a basal dressing after ridging. Chemical fertilizer application as a basal dressing was 8 kg/*sao* of nitrogen fertilizer (222 kg/ha of urea), 12 kg/*sao* of phosphatic fertilizer (333 kg/ha of P_2O_5), and 3 kg/*sao* of potash fertilizer (83kg/ha of K_2O), which were applied between potato plants when planting. When the plants reached 15 cm in height, 4 kg/*sao* of nitrogen fertilizer (111 kg/ha of urea) was applied as the first top-dressing. If potato leaves were still small and yellowish in color 10-15 days after the first top-dressing, some amount of chemical fertilizer could be applied again. About 10-15 days after the first top-dressing, plants were earthed up to promote tuber growth.

During the growing period, farmers have to be careful of disease and insect damage. When the disease and insect-forecasting brigade (*doi bao ve thuc vat*) of the cooperative instructs farmers to apply agricultural chemicals, farmers have to follow the instructions with regard to the type and amount of chemicals, and the time of spraying. If there is danger of wide-spread damage by disease or insect, the cooperative organizes a team to apply chemicals effectively to all the fields.

Harvesting begins in early March. If potato plants are still vigorous in the harvesting season, farmers cut the plants at the lower part of stem and leave them for 3-5 days. In this period, potato tubers in the soil become bigger and their epidermis hardens, allowing them to be stored for longer time. This method was introduced to CT in 1986, and called *vo gia* in Vietnamese, which means "harden skin".

Farmers have to follow the recommended cultivation method in order to control quality. For example, some farmers cultivated leafy vegetables and kohlrabi (*Brassica oleracea* L. var. gongylodes) along the foot of ridges. It was effective use of land. Such supplemental vegetable cultivation, however, has been prohibited by the cooperative since 1995, because the cooperative worried about its influence on the quality of potato.

There are two members of staff who guide and manage the potato cultivation during the cropping season. They contract with the cooperative every year. Outside the cropping season, they attend lectures organized by KVT Project to extend their knowledge of cultivation methods.

The cooperative also conducts experiments on potatoes in several farmers' fields. The experiments investigate the proper amount of fertilizer, the optimal cropping pattern, characteristics of new varieties, and so on.

Potato production in CT receives no financial or technical support from the province or district. Some experts from KVT Project visit CT and check potato growth several times during the cropping season. For example, in the spring season of 1998, Vietnamese staff of KVT Project visited 4-5 times and the Dutch experts did twice, at planting and harvesting time.

6.3.3 Storage

Before 1996, farmers in CT preserved their potato harvest on shelves built in a part of the house that was well-ventilated and out of the direct sunlight. Nevertheless, many seed potatoes rotted in the summer due to the high temperature and high humidity. CT, therefore, constructed a cold storehouse in 1997, which is kept at 4 ℃ all year round and can store up to 35 tons of potato[1]. CT stores seed potato from March until the next planting in November or December without loss of seed potato quality.

[1] At the end of 1998, CT started construction of another cold storehouse, which can store up to 35 tons. The total capacity to store potato at present is, therefore, 70 tons.

CT can use the cold storehouse to generate a profit. It stores potatoes and receives a storage fee from other cooperatives and institutions. CT started this potato storage business in 1998. The total amount of potato stored in 1998 was 11 tons, of which 5 tons was from three cooperatives in Nam Dinh Province, 4 tons from KVT Project, and 2 tons from the farmers in CT.

CT can generate further profit from the storehouse, by storing potatoes harvested in March and selling them in November-December, when the price reaches its highest level in the year. This marketing business also started in 1997.

6.3.4 Sales

Figure 6-2 shows a flow chart of spring potato produced by CT in 1998. The total production of 85 tons was distributed along two routes: supplied to the cooperative (66 tons) and for home consumption (19 tons). The latter was used for sale, human consumption, animal feed, and storage as seed potato by farmers.

Potato supplied by farmers to the cooperative (66 tons) was divided into two categories: one for payment to KVT Project based on contract (44 tons), and the other for sale by the cooperative (22 tons). The former was paid to KVT Project as the cost of stock seed potato after harvesting. The latter was divided into three categories: potato for sale to merchants and other cooperatives just after the harvest (0 ton), potato for sale after storage (18 tons), and loss during storage (4 tons).

The amount of potato supplied to merchants and other cooperatives just after the harvest in 1998 was 0 tons, because of the low yield due to disease damage, and because the cooperative had to give priority to the payment to the KVT Project. In 1997, when the production was higher than in 1998, the cooperative sold 60 tons of potatoes to four cooperatives in Ha Nam Province and one institution in Lai Chau Province. These cooperatives and institution got to know about the potato produced in CT through a TV program broadcasted by Nam Dinh Province, a promotional meeting on potato held by Vu Ban District, and publicity by the Seed Potato Center in Hanoi (*Trung Tam Khoai Tay Giong*). The selling price in 1997 was 1,800 dong/kg (10,000 dong = 100 Japanese yen = 0.8 USD in 1998).

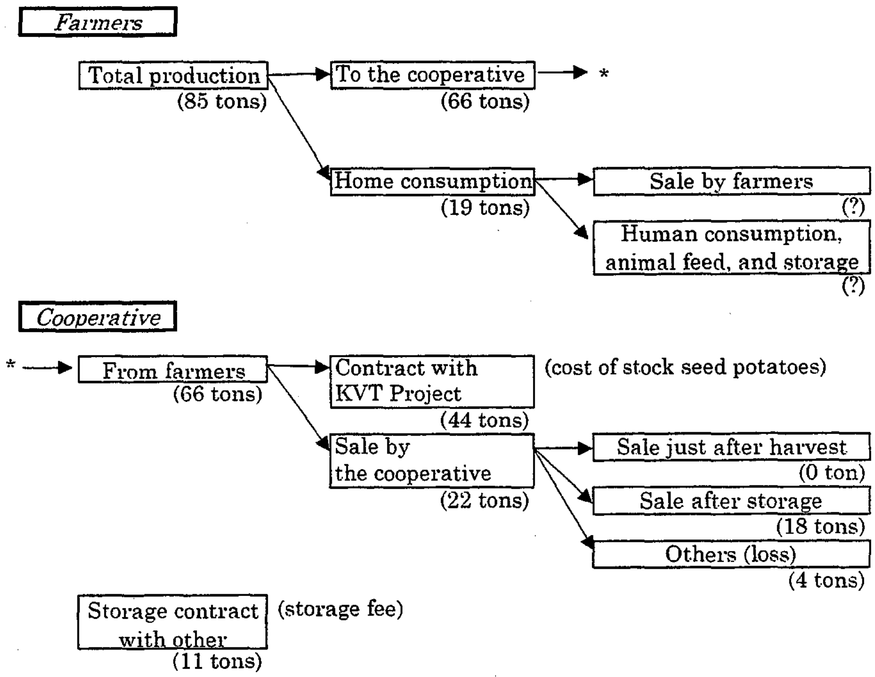


Fig. 6-2. Flow of spring potatoes produced by CT in 1998

The total amount of potato kept in the cold storehouse in 1998 was 33 tons, of which 22 tons was sold by the cooperative. The remaining 11 tons was stored at the request of other cooperatives. Of the 22 tons, 18 tons were sold in November, when the selling price reached 4,000 dong/kg, 2.2 times higher than that of March. Four tons were lost during storing because of bad ventilation.

While the cooperative initially sold its potato to customers who came directly to CT, it started more active marketing. Executive staff of the cooperative visited other cooperatives, explaining the cultivation method and the income and costs of potato production. The purpose of this activity, which was free of charge, was to increase the number of potato-cultivating cooperatives, to which CT could then sell seed potato.

6.4. Economics of potato production

In this section, the author evaluates the cooperative's economic activity by calculating the revenue, expenditure, and profits of the potato business in 1998. The potato business in CT is composed of three parts, cultivation, storage, and sale businesses. Here, I consider these in two parts, the cultivation business, and the storage and sale, because the latter two businesses are interconnected.

6.4.1 Revenues, expenditures, and profits of the cultivation business

6.4.1.1 The cooperative's revenues, expenditures, and profits

Before the planting season of potato, the cooperative purchases packaged materials for potato cultivation, which include stock seed potatoes, chemical fertilizers, and agricultural chemicals, and sell them to farmers. Table 6-2 shows the cost of packaged materials of the cultivation business. Stock seed potatoes are imported from Holland through KVT Project. The cost in 1998 was 405,000 dong/*sao*. Chemical fertilizers and agricultural chemicals are prepared by the cooperative. The amount of chemical fertilizers applied is based on the instructions issued by the cooperative, which farmers have to follow. The cost of chemical fertilizers in 1998 was 44,340 dong/*sao*.

Table 6-2. Packaged material costs of the cultivation business in 1998

Material	Amount (kg/*sao*)		Price per unit (dong/kg)		Cost (dong/*sao*)
Stock seed potato	45	×	9,000	=	405,000
Chemical fertilizers					44,340
N fertilizer (Urea)	12	×	2,100	=	25,200
P fertilizer (P_2O_5)	12	×	970	=	11,640
K fertilizer (K_2O)	3	×	2,500	=	7,500
Agricultural chemicals					19,350
Others					2,910
Total					471,600

The cost of agricultural chemicals consists of the cost of the chemicals themselves and labor costs for spraying. In paddy fields, farmers usually spray by themselves. What the brigade of disease and insect forecasting of the cooperative does is to announce outbreaks of insects and disease to the farmers and advise them of the type and amount of chemicals to be applied, and the time of spraying. In the fields designated for potato cultivation, however, the cooperative sometimes hires people to spray all the fields together in order to control insect and disease effectively, and they actually did so in 1998. The total cost of agricultural chemicals was 19,350 dong/*sao*. The cost listed above, therefore, makes up the cost of packaged materials, which was 471,600 dong/*sao*.

After the potato harvesting, the cooperative gets the costs of packaged materials, a tax and fees, and the service fee from farmers.

The cost of the packaged materials is the same amount as the cooperative provided before the planting.

A tax and fees are composed of an agricultural tax for the spring season, a fee to the cooperative's fund[2], a water fee for the government, an irrigation fee for the cooperative's pump, a management fee, a disease and insect forecasting fee, a fee for watchpersons, and so on (Table 6-3). The total cost of tax and fees was 32.55 kg/*sao* of unhulled rice, which is equal to 48,825 dong/*sao* in Vietnamese currency (rice price, 1,500 dong/kg). Service fee, which is kept in the cooperative's fund, included a fee of transportation, brokerage and so on. It was set at 77,175 dong/*sao* in 1998.

Table 6-3. A tax and fees of the cultivation business paid by farmers in 1998

Expenses	Cost (unit: kg of unhulled rice per *sao*)
Agricultural tax	9.1
Cooperative's fund	3.5
Water fee for the government	5.0
Irrigation fee for the cooperative's pump (**)	1.5
Management fee (*)	12.1
Disease and insect forecasting fee	0.8
Fee for watchpersons	0.2
Others	0.4
Total	32.6 (=48,825 dong/*sao*)

(*) 1.2 kg/*sao* was the cost for normal year, but 10.85 kg/*sao* is added for the cost of lining canals

(**) Irrigation two times (two and three days respectively) by the cooperative's mobile pumps during the season

[2] CT has established a fund called the cooperative's fund. The cost of infrastructure, such as building schools and canals, and social welfare are provided by this fund.

The cooperative's total profit of the cultivation business in 1998 was, therefore, equal to the total amount of tax and fee and service fee, which was 126,000 dong/*sao* (= 48,825 dong/*sao* + 77,175 dong/*sao*). All of these profits were kept in the cooperative as cooperative funds.

6.4.1.2. Farmers' revenues, expenditures, and profits in 1997 and 1998

Farmers' revenues, expenditures, and profits in 1997 and 1998 is shown in Table 6-4. As mentioned above, farmers purchase a packaged material for potato cultivation from the cooperative and pay back the cost, which was 471,600 dong/*sao*, to the cooperative after harvesting. In addition to that, they have to pay tax and fees and service fee, which were 48,825 dong/*sao* and 77,175 dong/*sao*, respectively. Farmers' total expenditure for potato cultivation to the cooperative in 1998 was, therefore, 597,600 dong/*sao*.

Farmers provide manure and labor for potato cultivation. They have to provide 650 kg/*sao* of manure by themselves, which is mixed with pig dung and rice straw. This was equal to 110,500 dong/*sao*, because 1 kg of manure costs 170 dong[3].

Labor costs include costs of cultivation management from planting until harvesting, transportation, and application of manure. Although labor cost is different between households and cultivation years, this amount in 1997 and 1998 was uniformly decided by the cooperative, and cost was 47,900 dong/*sao*.

Another revenue can be got from the potato harvest. In 1998, the average yield of potato was 427.7 kg/*sao*, and the selling price of potato was 1,800 dong/kg, which was equal to 769,860 dong/*sao*.

[3] Cost of manure is estimated by the cooperative.

The total farmers' revenue was, therefore, 928,260 dong/*sao*. Farmers' profit in 1998 was a balance between the revenues and expenditures, which was;

928,260 dong/*sao* - 597,600 dong/*sao* = 330,660 dong/*sao*.

Table 6-4. Farmers' revenues, expenditures, and profits form potato cultivation in 1997 and 1998

	1997	1998
Actual yield	697 kg/*sao*	428 kg/*sao*
Expenditures (dong/*sao*)		
Packaged material cost	625,500	471,600
Tax and fees*	31,785	48,825
Service fee	125,000	77,175
Sub-total	782,285	597,600
Revenues (dong/*sao*)		
Manure	110,500	110,500
Labor cost	47,900	47,900
Harvest	1,254,600	769,860
Sub-total	1,413,000	928,260
Profit (dong/*sao*)	630,715	330,660

* This was originally calculated as unhulled rice, which was equal to 24.45 kg/*sao* in 1997 and 32.55 kg/*sao* in 1998, when the rice-selling price was 1,500 dong/kg and 1,300 dong/kg, respectively.

Is this profitable compared with rice cultivation? The following is an estimation of profit on the assumption that rice planted in the same field as spring potato. Rice variety was *tap giao 1*, an improved variety. The total expenditure in 1998 was 135,275 dong/*sao*, which was composed of material costs and a tax and fees (Table 6-5). A tax and fees were the same as potato production. The service fee was assumed to be zero. The total revenue was 506,500 dong/*sao*, which was composed of manure and labor costs and harvesting. Manure and labor costs were estimated by the cooperative.

Table 6-5. Farmers' revenues, expenditures, and profits from rice cultivation in 1998

	Amount (kg/*sao*)		Price per unit (dong/kg)		Cost (dong/*sao*)
Expenditures (dong/*sao*)					
Material costs					86,450
Seed rice	1	×	10,000	=	10,000
Chemical fertilizers*					57,100
N fertilizer (Urea)	12	×	2,100	=	25,200
P fertilizer (P_2O_5)	20	×	970	=	19,400
K fertilizer (K_2O)	5	×	2,500	=	12,500
Agricultural chemicals					19,350
Tax and fees					48,825
Service fee					0
Sub-total					135,275
Revenues** (dong/*sao*)					
Manure	450	×	170	=	76,500
Labor cost					70,000
Harvest	240	×	1,500	=	360,000
Sub-total					506,500
Profit (dong/*sao*)					371,225

* The amount of fertilizer is based on an explanatory leaflet from the Nam Ha seed company (*cong ty giong cay trong Nam Ha*). The amount of manure and labor cost is based on the figures used by CT in analyzing farmers' economy
** Manure and labor costs were estimated by the cooperative.

The rice yield of *tap giao 1* in the spring season was 240 kg/*sao* (6.7 ton/ha) in 1998, and 237.2 kg/*sao* (6.6 ton/ha) in 1997. The selling price of rice was 1,500 dong/*sao* in 1998, and 1,300 dong/*sao* in 1997. The revenue from rice harvest was 360,000 dong/*sao* in 1998 and 308,360 dong/*sao* in 1997. The profit in 1998 was, therefore, 371,225 dong/*sao*.

The result of profit comparison is shown in Table 6-6. In 1998, rice cultivation was more profitable than potato cultivation, because the potato crop was damaged by disease and the selling price of rice rose. According to Fig. 6-1, however, the frequency of a poor harvest of potato such as that of 1998 is twice in a decade. In the remaining eight years, potato cultivation is approximately two times more profitable than rice cultivation.

Table 6-6. Comparison of profit between rice and potato cultivation in 1997 and 1998

	1997		1998	
	Potato	Rice	Potato	Rice
Yield (kg/*sao*)	697.0	237.2	427.7	240.0
Selling price (dong/kg)	1,800	1,300	1,800	1,500
Expenditure (dong/*sao*)	782,285	118,235	597,600	135,275
Revenue (dong/*sao*)	1,413,000	454,860	928,260	506,500
Profit (dong/*sao*)	630,715	336,625	330,660	371,225

6.4.2. Revenues, expenditures, and profits from the storage and sale businesses

6.4.2.1. Gross revenue of the storage and sale businesses

Gross revenue (*tong thu*) of the storage and sale businesses in 1998 was 84,709,700 dong, of which (1) 11,655,700 dong was revenue from storage, and (2) 73,054,000 dong was from sale of seed potato (Table 6-7.).

Table 6-7. Revenue from storage and sale of seed potato in 1998

	Amount (kg)	Unit price (dong/kg)	Total (dong)
Revenue from storage			
3 cooperatives	4,651	1,000-1,200	5,381,700
KVT Project	4,000	1,000	4,000,000
CT members	2,274	1,000	2,274,000
Subtotal	10,925		11,655,700
Revenue from sale of seed potato			
KVT Project	17,780	4,000	71,120,000
Merchants and others	475	1,800-4,120	1,934,000
Subtotal	18,255		73,054,000
Total			84,709,700

In 1998, the cooperative stored 11 tons of potato in the cold storehouse, of which 5 tons was from three other cooperatives, 4 tons from KVT Project, and 2 tons from farmers belong to CT. The total revenue was 11,655,700 dong.

After the cooperative purchased potatoes from farmers and stored them in the cold storehouse, they sold the potatoes to KVT Project, merchants in the district, and others. When they purchased the potatoes, the price was approximately 1,800 dong/kg. When they sold the potatoes after storing, the price was a maximum of 4,120 dong/kg. The total revenue from sale of seed potato in 1998 was 73,054,000 dong.

6.4.2.2. Expenditures of the storage and sale businesses

The total expenditure of the storage and sale businesses in 1998 was 54,878,720 dong. Of this, 30,535,200 dong was for purchase of seed potato, 12,885,600 dong was the cost of losses, and 11,457,920 dong was for maintenance fees (Table 6-8).

Losses during storage were due to rotting as a result of bad ventilation. They amounted to 4,312 kg.

The cooperative stored 32,211 kg of potato, including 21,286 kg for sale and 10,925 kg stored at the request of other cooperatives and KVT Project. The amount of potato for sale decreased from 21,286 kg to 16,974 kg due to the loss of 4,312 kg. This resulted in a shortage of 1,281 kg relative to the contracted amount for sale of 18,255 kg. The cooperative thus bought the 1,281 kg of potato back from KVT Project. The actual amount of potato sold by CT to KVT Project was, therefore, 16,499 kg (17,780 kg - 1,281 kg).

Maintenance fees totaled 11,457,920 dong, including transportation, air conditioner management, electricity, bags for sale, and so on.

Table 6-8. Expenditures of the storage and sale businesses in 1998

Items[1]	Amount (kg)	Unit of price (dong/kg)	Total (dong)
Seed potato for storage[2]	16,974	1,800	30,535,200
Cost of Losses			
Loss during storage	4,312	1,800	7,761,600
Re-purchase from KVT Project	1,281	4,000	5,124,000
Subtotal			12,885,600
Maintenance fees			
Transportation			965,000
Air conditioner fee[3]			2,040,000
Electricity[4]			4,125,000
Bags5			3,064,000
Others			1,263,920
Subtotal			11,457,920
Total			54,878,720

Note: 1. See the text for details
2. Including 10 kg potato without charge
3. Air conditioner management fee (2 persons/season)
4. Electricity (550 dong/kW × 40 kw/day × 187.5 days)
5. Bags for sale (11,200 dong/bag)

6.4.2.3 Profit of the storage and sale businesses and its distribution

The profit of the storage and sale businesses was 29,830,980 dong, which was the balance between the gross revenue of 84,709,700 dong and the expenditure of 54,878,720 dong (the depreciation cost of the cold storehouse is mentioned later).

This profit is appropriated as the cooperative's income. The cooperative's total income is composed not only of the profit of the storage and sale businesses, but also that of seed rice and chemical fertilizer sales. The distribution of the cooperative's total income was decided at a meeting of the executive staff of the cooperative, commune, and district.

In December 23, 1998, the cooperative invited a deputy director and the head of the agricultural department of Vu Ban district, secretary, vicesecretary, director, vice-director of Thanh Loi commune and held a meeting to report their statement of accounts for the second half of 1998. The representatives of the cooperative were the six executive members of staff, i.e., the director, two vice-directors, the head of accounting, the head of inspection, and the head of agricultural planning. At the meeting, the total income for the second half of 1998 was reported as follows:

storage and sale businesses of potato, 29,830,980 dong (87.2 %)
seed rice sale, 2,999,020 dong (8.8%)
chemical fertilizer sale, 1,389,950 dong (4.0%)

The total income was 34,219,950 dong[4]. The profit from the cultivation business was not reported at the meeting, but appropriated to the cooperative's fund.

The commune director proposed the following distribution of the income:

(1) bonuses to the executive staff and farmers of the cooperative; 16,330,000 dong
(2) the depreciation cost and payment for the cold storehouse, 15,000,000 dong
(3) the cooperative's fund, 2,889,950 dong

The bonuses to the executives was substantially a reward for the potato business, especially for the storage and sale businesses. It was decided by

[4] At the meeting, the head of the cooperative reported that the total income was 34,330,000 dong. The figure in this paper is based on the cooperative's document of 1998.

the commune that the amount should not exceed 100 percent of their own regular salary. The remainder was paid to farmers who achieved a high rice yield as a production bonus.

The total of depreciation cost and payment for the cold storehouse is not fixed. Although it had been 34,000,000 dong in 1997, it was reduced to 15,000,000 dong in 1998 because of the lower potato yield and the loss of potatoes due to rotting during storage. The cooperative adjusted the depreciation cost and payment for the cold storehouse, which depended on profit, because the total construction cost was paid by the cooperative's fund and KVT Project. The rest of the income was added to the cooperative's fund.

According to the decision of the meeting, besides their regular salary, the executive staff of the cooperative could get a bonus from the cooperative's income, which was mainly derived from the storage and sale businesses.

Since when could the executive staff get a bonus? The amount of bonus is not found in a statement of accounts. According to interviews to executives, although they did not have received a bonus in the past, it has been paid to the executive staff since about 1990, and the seasonal amount was about one million dong per person. In CT, a bonus paid to the executive staff was not only considered as reward for the cooperative businesses by the executives, but also accepted both by the commune and the general meeting of CT members.

6.5. Roles of cooperatives

This chapter deals with spring potato management by the cooperative, including the cultivation, and the storage and sale businesses, and focused mainly on the revenues, expenditures, and profits of those businesses. The executive staff of the cooperative actively managed the potato business from the purchase of stock seed potato through cultivation management and storage to sale of product, and produced a profit for the whole CT. In order to generate profits both for the potato cultivation farmers and the whole of CT, they controlled the packaged material cost and the cooperative's profit according to fluctuations in climatic conditions and market prices. At the same time, the executive staff received a bonus as reward for the potato business besides their regular salary.

Although CT is a village organization composed of almost all farmers within an administrative boundary, at the same time, it is considered to be an autonomous village, judging from the economic activity such as potato business and social activities, which carries on a public undertakings and welfare works by themselves[5]. Why did the cooperative manage the potato business as a CT's business? If the farmers involved were to establish a potato production association, would its the economic activity function better than that of CT?

The merits gained from the fact that the potato business was run by CT are: (1) the cooperative could raise funds from many people for the construction of the cold storehouse and the purchase of seed potatoes, (2) the cooperative got information on potato cultivation through the province and district, (3) the cooperative functioned as an arbitrator to adjust and allocate the fields for potato production, (4) the cooperative could easily find merchants and institutions to which to sell their potatoes, because the establishment of the business by the cooperative coincided with the government policy and the potato business in CT was publicized through television and the agricultural departments of the district and province, and

[5] See Iwai (1997) regarding the cooperative's management and social function of CT.

(5) the potato business could be trusted by non potato growers, because the potato growers paid profit to the cooperative's fund to improve welfare in CT. Conversely, the demerits are: (1) the potato growers are mainly located in the old *xa* Bach Coc, and other farmers cannot profit from the cultivation business, (2) not all profit is returned to the growers, because part is paid into the cooperative's fund and used for public undertakings and welfare works, (3) profit is not always reinvested in the business, and (4) the per capita profit from the cultivation and the storage and sale businesses is lower than it would be if the growers formed a production association. In other words, merits are funding, information, function as an arbitrator, the coincidence with government policy, and the cooperative's welfare works; and the demerit is economic inefficiency as a profit-making organization. Because of the merits of funding, information, and the coincidence with government policy, CT became an economic organization based on almost all villagers. To improve its economic efficiency as a profit-making organization, which reduced the fact that CT is composed of almost all villagers, CT paid rewards to the executive staff, thereby motivating them to efficient management. As a result, CT became an organization with two purposes: the pursuit of economic efficiency and the promotion of welfare works in CT.

Economic activity of CT is not necessarily rational from economical point of view. So long as the central and local government, however, do not have enough funds to engage in public undertakings and welfare works at the village level, villagers have to get funds by themselves and do public undertakings and welfare works in their own villages. In that sense, economic activities by farmers' associations such as cooperatives should be promoted.

Chapter 7 General discussion and conclusion

One of the main characteristics of the rural Red River Delta is overpopulation. Agricultural population occupies about 80 % of the total population in the rural areas. Overpopulation in rural areas means, in other words, that the agricultural land per person is limited. In order to support this great population without expansion of agricultural land, agricultural activities have to be intensified. Although the high population density in the Red River Delta suggests that the agricultural system in the Red River Delta is intensified, it is not necessary to be clear about the actual situation.

For the purpose of understanding the intensified agricultural system in the delta, this study focused on the agricultural system of a village. The limiting factors of cropping patterns, mainly rice cultivation as a crop for self-sufficiency, vegetable cultivation as a cash-crop, and potato cultivation as a cash-crop managed by the cooperative, were agro-ecologically analyzed from the aspects of physical conditions and cultivation techniques. Furthermore, on the basis of the analysis, three factors of intensification, namely, land, labor, and capital intensification were evaluated.

Land intensification

In order to increase the productivity per unit area by improving the use of land, spatial and temporal utilization of fields have to be more efficient. Multiple cropping is required. Triple cropping of rice was, however, difficult, unless early maturing (less that 3 months) varieties with tolerance to the conditions of low temperature and low sunshine duration are introduced. It is, therefore, considered that land intensification of the fields in Types 5, 6, 7, and 8 in CT had reached the limit, because rice was already being cropped twice a year. Although, rice was planted once a year or never in the fields of Types 1, 2, and 3, it was quite difficult for farmers to add one or more rice crops to these fields, because of a difficulty in irrigating due to the high elevation and sandy soil of the fields. On the other hand, it is true that rice can be planted in the fields of Type 4, but the area is small. To increase the productivity per unit area by improving the use of land was, therefore, almost impossible. Land intensification of rice in CT has already reached the limit.

The amount of vegetables planted a year could be increased, depending on the type of field. As shown in Chapter 5, the occupation ratio of the vegetable fields throughout the year (Types 1 & 2), which were 11.9 % of the total agricultural land, was 80 – 92 %. It was difficult to increase the number of crops in those fields. In fields of Types 3, 4, 5, and 6, it was possible to increase the number of vegetables, because the period which crops were not planted was longer than that in fields of Types 1 & 2, and the crops in these fields included not only leafy vegetables but also upland crops with a longer growing-period such as kohlrabi, potato, sweet potato, and so on. If farmers converted to crops of leafy vegetables with a short growing period, the occupation ratio would increase. The fields of Types 3, 4, 5, and 6 were 33.3 % of the total agricultural land. Although to increase the number of crops in these fields would result in more intensification of landuse, one of the limiting factors preventing further intensification was economic condition.

Labor intensification

In order to evaluate labor intensification of agricultural system in CT, it is needed to understand the relationship between the working hours per unit area and the final yield, because farmers determine the working hour on the basis of their own rational reasons, and, through the analysis of the determinant factors, an evaluation of the labor intensification of the system is possible.

The ratio of the final production to the working hours is defined as "labor productivity" and formulated in the following expression:

Labor productivity = Production / Working hour

Labor productivity is, therefore, affected by the relative value of production and working hours. Even though the working hours increase, labor productivity may not decrease, if production increases. Conversely, even though working hours decrease, labor productivity can decrease, if production decreases greatly. In this section, the effects of increase and decrease in working hours on rice and vegetable cultivation systems is analyzed.

Increase or decrease of working hours for rice cultivation did not link to those of rice yield in either the spring and summer seasons, because there was no significant correlation between the working hours and yield. In the summer season, there was even a negative correlation between them (See Table 4-5). This meant that the more the working hours were the more the yield was. In both cases, there was no significant correlation between the working hours and yield, and labor intensification, therefore, has reached the limit under the present conditions in the sense that more input has not increased land productivity.

If working hours are not reflected in the rice yield, why would farmers not try to increase the labor productivity by the reduction of working hours?

The author considers that, even though labor productivity is low, farmers do not reduce labor input, because there is a lot of cheap labor in rural areas due to overpopulation, as Chayanov (1957) mentioned. Working hours for rice cultivation is determined in order to achieve self-sufficiency. It did not always maximize the economic efficiency of input to output.

This, however, did not mean that farmers invested useless labor in rice cultivation. In terms of physical conditions and cultivation techniques at the farmer level, working hours for rice cultivation were determined by rational reasoning. For example, transplanting and harvest required the most working hours among the agricultural practices. Is it possible to introduce agricultural machines to reduce agricultural labor in CT? In villages in the Red River Delta, where wages continue to be at a low level due to overpopulation, there is no need for farmers to purchase relatively expensive machinery. Agricultural machinery will not become common in the Red River Delta under the present conditions. On the other hand, can a cultivation technique, without more capital input, be introduced in order to reduce labor for farmer? For example, is it possible to introduce the broadcasting method to replace transplanting? The author considers that it is difficult in the low land areas of the Red River Delta, including CT. Even though farmers harrow carefully before broadcasting, young rice plants just after broadcasting have to compete seriously with weeds in the spring season, because the initial growing of rice is not vigorous due to cold temperatures and low sunshine duration. As long as effective and cheap herbicide does not become common, the broadcasting method of rice will not expand. In the summer season, the broadcasting method would cause flood damage more frequently because the height of the rice plant is less than if it is transplanted. The broadcasting method will not become common as long as flooding is not controlled and there is no cheap and effective herbicide. In any case, labor-saving techniques for rice cultivation, which need more investment, would not be accepted by farmers in the Red River Delta under the present conditions. It will be accepted when farmers have the incentive to reduce the labor needed for rice cultivation in order to expand income sources resulting from more industrialization or commercialization.

In vegetable cultivation, there was no correlation between working hours and the final profit. It was determined by economic factors.

If it is true that the profit was not reflected by working hours, why would farmers not try to increase labor productivity by reducing the working hours for vegetable cultivation? The author considers that, like rice, it is because there is a lot of cheap labor due to overpopulation. Irrigation, which was done by human power, required the most working hours among the agricultural practices. The introduction of small scale pumps would greatly lighten the farmers task. Farmers, however, did not invest in the pumps. They will not invest in techniques such as pumps to reduce labor until labor and capital input is not reflected in the final profit when price of vegetables goes up.

Harvesting and sale were the second most working hours among agricultural practices for vegetable cultivation. Except for the case of selling vegetables to middle persons, individual farmers conducted the process from harvesting through processing to the selling of vegetables. Can not farmers in CT form an association to process, transport, and sell them cooperatively? My answer to this question is negative, because fluctuation in vegetable-price is big, there is little information on markets, dealings on a large scale are risky due to the small scale of the market, and so on. Improvement in the infrastructure is needed to promote vegetable sales.

Capital intensification

Capital inputs include chemical fertilizers, manure, and agricultural chemicals. In order to evaluate the impacts of capital intensification on agricultural system in CT, the relationship between these capital inputs per unit area (capital intensification) and the final yield (or profit) is essential.

In the spring rice cultivation, there was a significant correlation between the amount of chemical fertilizers and yield. Therefore, if farmers use more chemical fertilizers, they can expect to get a greater yield of rice. Actually, however, they did not have the incentive to invest more in rice cultivation, because rice was planted to achieve self-efficiency, and the surplus of labor and capital was transferred to vegetable cultivation as a cash crop.

In the summer rice cultivation, there was no significant correlation between capital inputs and yield. Due to flood damage, capital inputs were not reflected in the rice yield, and there was no incentive for farmers to invest in more capital inputs to get a greater yield of rice.

In the vegetable cultivation, no significant correlation between capital inputs and the final profit was observed. When, where, and to whom to sell vegetables affected the profit. Not physical conditions and cultivation techniques, but socio-economic conditions were the main determinant factors of the final profit of vegetable cultivation.

Conclusion

Land, labor, and capital intensification of the summer and spring rice and vegetable cultivation in CT is summarized in Table 7-1.

This table shows that almost all indices of intensification reached the limit, except for land intensification of vegetables and capital for the spring rice. The limiting factors were, however, not the same among them.

Although the limiting factors of land and capital intensification for rice cultivation were physical conditions, that of labor was determined by economic conditions. Under the conditions of overpopulation, in other words, low wages, it is unlikely that shortage of labor would become a limiting factor in the agricultural system. Furthermore, it should be easy for people to change natural resources by using human power. This continuous improvement would technically overcome the limiting factors originating from the physical conditions and farmer level cultivation techniques in the agricultural system. As a result, the determinant factors of the agricultural system in an overpopulated area is mainly due to socio-economic conditions. Socio-economic revolution, therefore has had a great impact on the agricultural systems in rural areas, such as the villages in the Red River Delta after *doi moi*.

Table 7-1. Land, labor, and capital intensification of the summer and spring rice and vegetable cultivation in CT

	Spring rice	Summer rice	Vegetable
Land intensification	Limit, due to nature	Limit, due to nature	Not limit, due to Econo.
Labor intensification	Limit, due to Econo.	Limit, due to Econo. and nature	Limit, due to Econo.
Capital intensification	Not limit, due to Econo.	Limit, due to nature	Limit, due to Econo.

* Note: "Limit" and "Not limit" shows whether intensification reached the limit or not. "Nature" and "Econo." mean a limiting factor if the intensification reached the limit, and a reason if not the limit.

Another finding from the study in CT was the roles of the cooperative in terms of agricultural production at the village level. Through the introduction of new crops and varieties, services for insect and disease forecasting, water management, and so on, the cooperative technically supported both the increasing of rice and the expansion of vegetable cultivation fields, and contributed to intensified cropping systems.

In addition to the technical support, fund-raising activities by the cooperative is worthy of mention. As long as it did not compete with rice for self-sufficiency and vegetables as a cash-income source at the farmer level, the cooperative gave farmers the opportunity of income building. The cooperative took advantage of being a cooperative and tried to overcome the socio-economic difficulties which the farmers could not do.

Rice cultivation for self-sufficiency and vegetable cultivation as a source of cash income by farmers, and technical support for both rice and vegetables and fund-raising activities by the cooperative were the basic farming strategies of the people whose main economic activity was agriculture in CT.

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